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A comprehensive analysis is presented of the cost of a schoolhouse and the processes of planning and financing it. In focusing on the elements of school building costs, cosideration is given to approaches to school construction and financing in other countries and to the historical evolution of schoolhouse design in the U.S. An analysis is presented of planning, building, and financial factors involved in modern-day school construction, and predictions are made on changes in education and society and their influence on future schoolhouse construction. (FS)

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the Cost of a Schoolhouse

A REPORT FROM EDUCATIONAL FACILITIES LABORATORIES

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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Educational Facilities Laboratories 1960

the Cost of a Schoolhouse

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WHY

This book is about inanimate things—bricks and dollars. It is also about children and education. But primarily it deals with the cost of a schoolhouse and the process of planning and financing it.

Why a publication on school costs? There are two reasons. The first is that the problem of school building is quantitatively so great. The second is the number of special circumstances that distinguish the school building program from any other building program.

Schools are big business today. One-fourth of the people in the United States spend their working day in schools as pupils or teachers. The value of existing school plant, public, private, and church-related, is conservatively judged to be on the order of $30 billion. This is roughly four times the assets of General Motors. Educational building for 1960 is estimated at $3.2 billion, more than the assets of our richest railroad, the Pennsylvania.

There are other reasons, aside from the magnitude of the problem, why school costs are so often discussed and debated in the cities and their suburbs, the towns, and the villages. No public building is more publicly planned, built, and financed than is the school. The question of whether to build and what to build hits the typical citizen in two sensitive spots—his children and his pocketbook.

Decision-making in regard to the school building project is more complex and diffuse than is common in other fields. While Los Angeles currently builds schools at the rate of a million dollars a week, in many school districts the question of whether and what to build comes up every two or five or ten years. Often, too, the decisions must be made by a board of education with little building experience, who are guided by a superintendent with little building experience and an architect who, whatever his other qualifications, may never have built a school before, and carried out by a contractor who is tackling his first big job.

Schools are for children. Where children walk, sentiment and myth are never far behind. Decisions have to be made which will affect the safety, health, and psychological and academic development of children; and these decisions must be equated to dollars and cents.

Schools are for education. They are erected to accommodate the process of instructing youth. Yet the form and content of education are in turn affected by the building which contains them.

While schools are shaped by the community, conversely the community is shaped by the schools it builds. Every school affects the spirit, the looks, the desirability, the assessed wealth, and the future of the community which builds it.

Everywhere there is the search for economy. But economy is a slippery word. To some it means cheap. To others it means a building with a minimum of maintenance. To still others it means a building which will continue to function effectively into the twenty-first century.

The problems are global. Counting all the peoples of the earth there are about three billion of us today. Our numbers are mounting fast; consider that of all the human beings who have ever lived on "this one inhabited star" one-sixth are today alive. Before 1980 the world will have another billion, and by the year 2000 today's population will have doubled. In effect we have only 40 years in which to build an additional world. The present world is very much in the position in which Alice and the Queen found themselves. "Now, *here*, you see," said the Queen to Alice, "it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that."

Some nations have had organized education for centuries; others are getting schools now for the first time. Some of the schools will be bamboo huts in Laos or crude metal-roofed buildings in Nigeria, some will be glass and concrete structures in West Germany, some will be brick and frame in Nebraska.

Here at home we will need over 400,000 classrooms by 1964. Of these about 133,000 are needed now.

The approach to the problem will vary in each country according to its traditions, its resources, and its own particular way of organizing and operating its schools. Of the 57 nations who participated in the International Bureau of Education-UNESCO study on "Expansion of School Building" (1957), a good two-thirds have an educational system in which major education decisions are made by the central government. Most of the remaining third of the countries have systems in which the national and regional governments share responsibility. Very few countries have systems of local control similar to ours. France, for instance, has a fairly rigid system of centralized control of building; its neighbors, Italy, West Germany, and Switzerland, have comparatively decentralized systems. West Germany, perhaps because of the occupation, is one of the few countries in the world that has adopted our system of local control.

In the Soviet Union, although the over-all direction of school construction is based upon a single national plan, each of the member republics establishes its own plan for carrying out directives. The USSR is also decentralizing as rapidly as possible, giving more and more control to local regions.

As for the actual cash to pay for the schools, the sources vary widely, too. In a few cases, such as New Zealand, Portugal, and Australia, the central government assumes most of the financial burden. Roughly half of the 57 countries, including France, England, Italy, and Japan, have mixed systems in which the central, regional, and local governments all make contributions toward the building of schools. In about one-fourth of the countries, such as in Rumania, Peru, and Tunisia, the state supplies a large part but not all of the funds. In another quarter of the countries, among them Sweden, Finland, and Switzerland, the money is primarily local. In only a very few countries, such as Israel, West Germany, and the United States, is the money raised almost wholly by the local community or state.

Some countries raise money for schools by popular subscription. In Cambodia, funds are raised by house-to-house appeals for private funds, by donations from wealthy people (a method not unknown in the United States), and by the use of the tombola, a card game-lottery device.

In Ceylon rural development societies and local P.T.A.s are encouraged to raise half of the cost of a school with the government supplying the rest. In Equador there is a 20-centavos school stamp on documents and correspondence and a school tax on salt. In Israel some money is raised by lotteries and collections by parents. In Egypt an individual or an organization can get a building priority for a desired school by offering the government a free site and by putting up fifteen hundred Egyptian pounds.

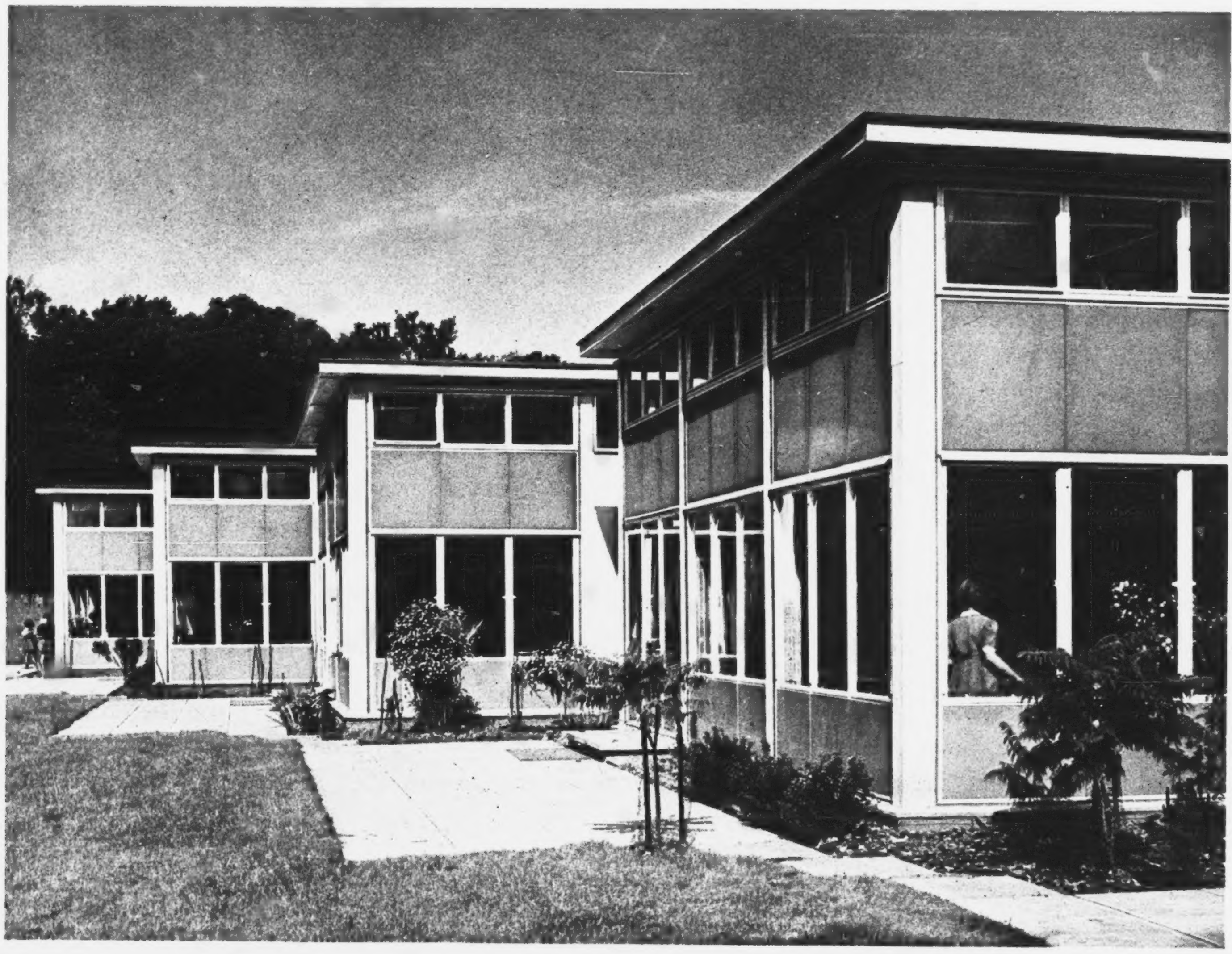
Different countries also devote varying percentages of their national educational expenditures to school buildings. It is not always an easy matter to compare such expenditures, nor are the resulting figures wholly reliable since countries tot up their expenditures in quite different ways. The Soviet Union, for example, reports the startlingly low figure of 2.3 per cent of their total educational money as being devoted to building schools. But this does not include an equivalent number of schools built and paid for by the collective farms.

Australia spends 17 per cent on buildings. Brazil spends 19.4 per cent; Canada spends 12 to 30 per cent depending on the region. Haiti lays out 30 per cent, New Zealand 21.5 per cent, and Cambodia 11 per cent. The United States, which was spending about 22 per cent in 1955–1956, is roughly in the upper middle class among nations of the world.

Just as there are different methods of operating and financing education, so there are many differing approaches to the problems of what kinds of schools to build and how to build them out of what materials. Yet a glance at the international scene reveals several broad trends in the ways in which various countries attack the problem.

Perhaps the most novel assault and certainly one of the most productive is embodied in the principle of the national school development and research organization, a method that is in practice or gaining acceptance in such countries as Britain, Belgium, Egypt, and the Netherlands.

The country that seems to have carried this furthest is Great Britain, which for the past few years has had an organization known as the Architects and Building Branch in the Ministry of Education. Within



Great Britain

Great Britain's school building economies have come from the use of repetitive modular units as in the Templewood Junior and Infants' School (above) by the Hertfordshire County architect, and through space savings. London's Mayfield School extension below, Powell and Moya architects, combines a large assembly hall, divisible into small lecture rooms, with a dining area and kitchen.

this division, a Development Group was set up for research and the dissemination of information resulting from research. The Group has made extensive studies of general problems of planning as well as of particular points such as fire safety and the use of color.

In order to test the theories it produces, the Group has constructed, in conjunction with local authorities, several test or model schools to provide a proving ground for experimental designs and techniques. The results of the tests are made available to the authorities and private architects through a series of Building Bulletins, circulars, lectures, and informal talks.

Since 1949, the British have been able to make some dramatic reductions in school building costs. In primary schools they have reduced the number of square feet devoted to each pupil by 38 per cent and the cost per pupil by 24 per cent. In high schools the reductions have averaged 33 per cent in the square footage per pupil and 21 per cent in cost per pupil.

Most of these savings have been made not by simply reducing the size of classrooms and cramming more children into the room but by the use of an increasingly popular device—the dual use of space. Corridors are incorporated into classrooms, the entrance halls are used as dining areas as well, and sliding or movable partitions are used to increase or decrease the size of rooms depending upon the needs of the moment.

Another broadly adopted trend is toward the use of model plans. Almost every country has experimented with this approach, and some countries have even held architectural competitions to produce model ideas that could be adapted for local use. Many of these countries specifically attempt to avoid the imposition of compulsory stock or standard plans on local communities or architects. The model plans are produced to serve just the purpose of a "model"—something to be used if it is helpful.

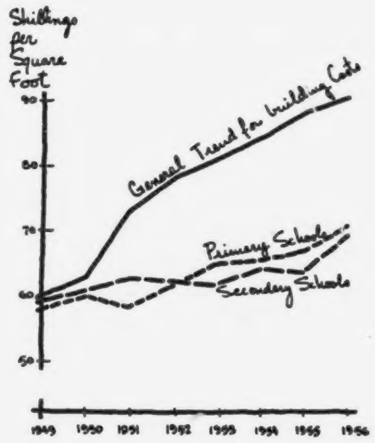
A third dominant trend is the scheme of building schools in stages, a device not unknown in this country; in some countries, such as Czechoslovakia, West Germany, and Poland, this approach has become official doctrine. In Czechoslovakia, for instance, the classrooms and the physical education facilities are built first, then the dining areas, and then the extra-scholastic buildings. In West Germany there is an added insistence that the whole building must be planned from the start so that it will emerge when finished as an harmonious whole.

Western Europe, in general, has a strong tradition of insisting that its schools be surrounded with handsome landscaping and decorated with genuine works of art. Many schools, even city schools with limited sites, will feature flower gardens, plantings, fountains, or pools. Many European governments require by law that a certain percentage of the construction cost of any school must be put into creative works of art for both the interior and exterior of the building. Wall murals, sculpture, or paintings are almost always found in European schools. Often the school staff will contain a full-time gardener, and many times the children themselves maintain the flowers during vacations.

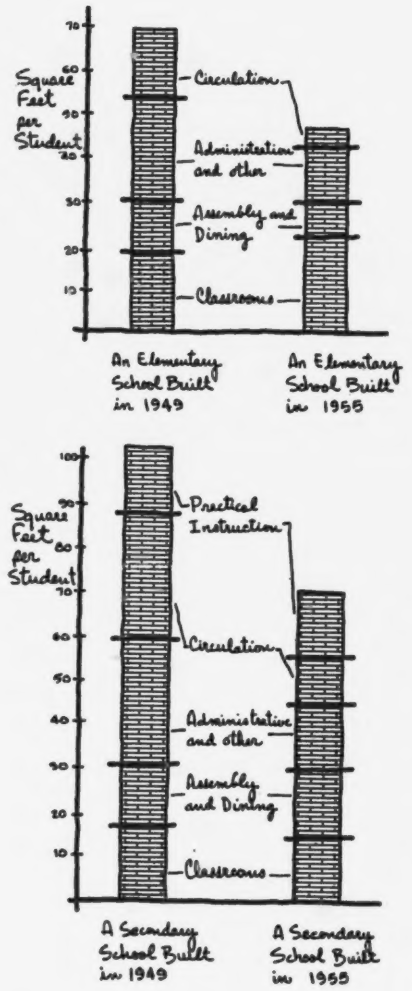
In addition to these broad trends, there are many individual examples of unusual approaches to school building problems.

In Hamburg, Germany, there are high schools of three to four

Source: Ministry of Education Pamphlet No. 33. **The Story of Post-War School Building.** London, 1957.

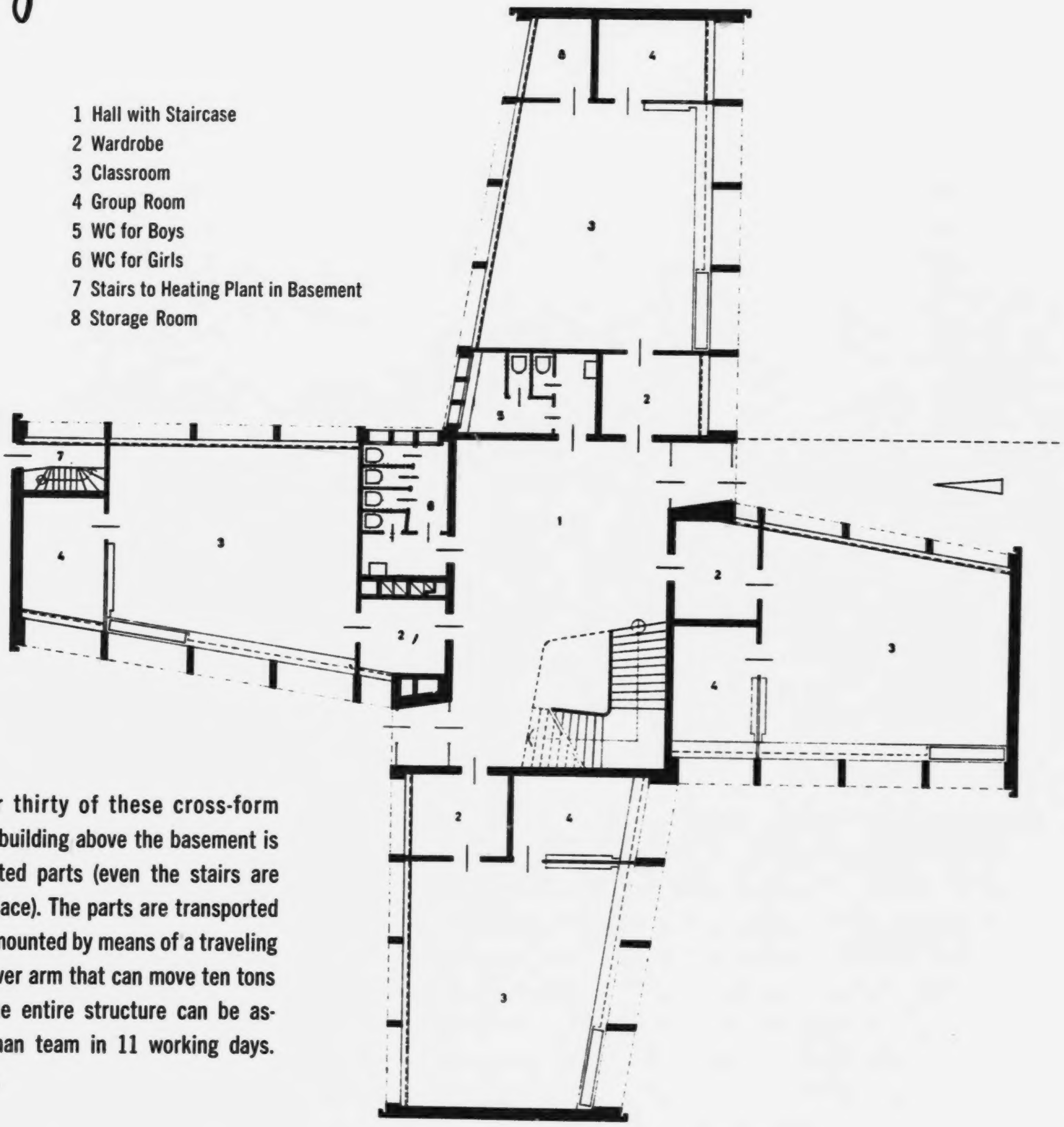


Trends in British Building Costs



A Comparison of British Primary and Secondary Schools Built in 1949 and 1955

Germany



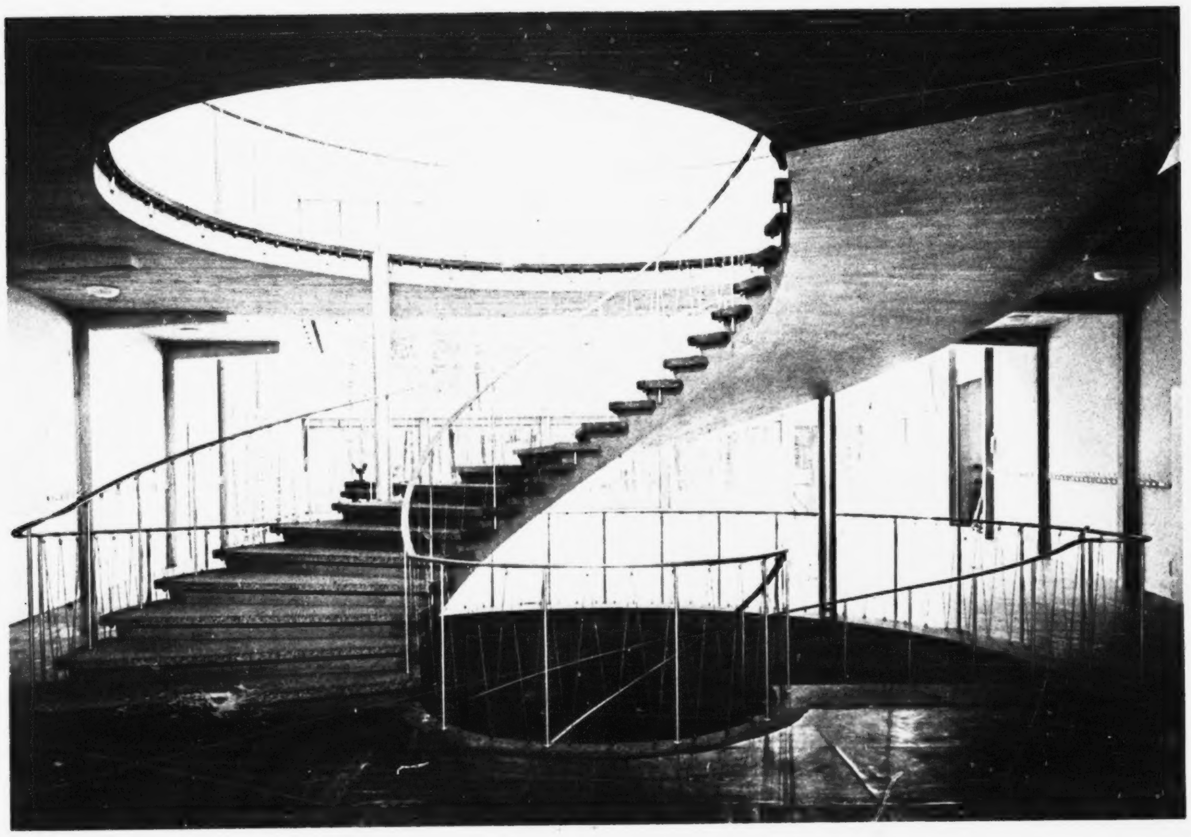
1 Hall with Staircase
2 Wardrobe
3 Classroom
4 Group Room
5 WC for Boys
6 WC for Girls
7 Stairs to Heating Plant in Basement
8 Storage Room

Hamburg has over thirty of these cross-form schools. The entire building above the basement is made of prefabricated parts (even the stairs are just clamped into place). The parts are transported in special cars and mounted by means of a traveling crane with a cantilever arm that can move ten tons with one sweep. The entire structure can be assembled by a six man team in 11 working days. Paul Seitz, architect.

stories built in the form of a cross. Each of the four wings of the cross contains a single set of classroom units, providing light from both sides of the room. Where the wings meet in the middle of the cross there is a central area used for assembly, dining, and administration.

England has experimented with campus-type high schools broken up into four or five smaller "houses," each accommodating 150 boys and 150 girls. Many European schools also contain living quarters for the headmaster and headmistress; Hamburg, for instance, has built apartment buildings for teachers in order to help solve the teaching shortage.

Le Corbusier, the famed French architect, has accomplished a novel



The great center hall in the Tempelsee Elementary School, Offenbach, Germany. Adolf Bayer, architect.

arrangement in the widely noted housing development he constructed in Marseilles. He put the primary school on top of the development and the children go up to school.

Some countries, notably Australia, Switzerland, and Canada, are attempting to meet the problem of shifting school population by experimenting with transportable and demountable classrooms. When a classroom is no longer needed in one place but desperately needed in another, it can be picked up and moved—even as in Los Angeles, which uses 3,300 transportable classrooms, or in San Diego, where 23 per cent of the city's enrollment is housed in movable cottages.

Through the use of model plans and special financial incentives to the builders, Egypt has been able to erect schools with 16 classrooms, an auditorium, and a workshop for art in the short space of 16 weeks.

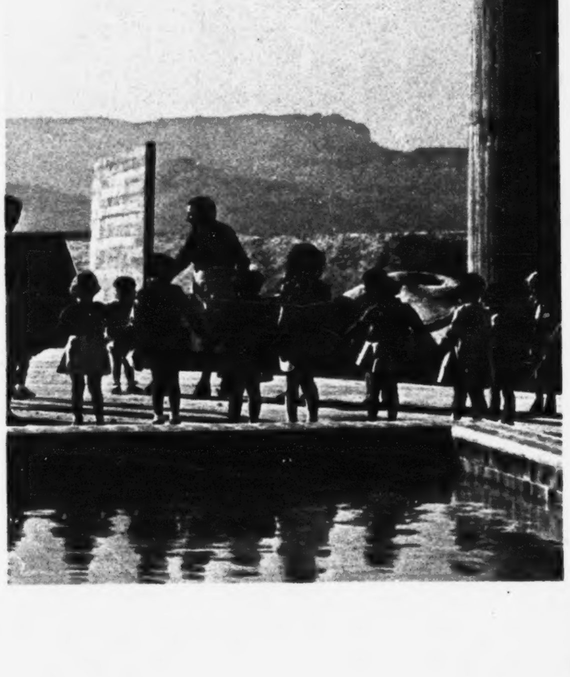
The Soviet Union, Nationalist China, and Bulgaria, among others, have systems of voluntary labor by which members of a community can pitch in and help build schools. The local community is expected also to contribute building materials and often sites. In the USSR high school students help build schools as part of the shop curriculum.

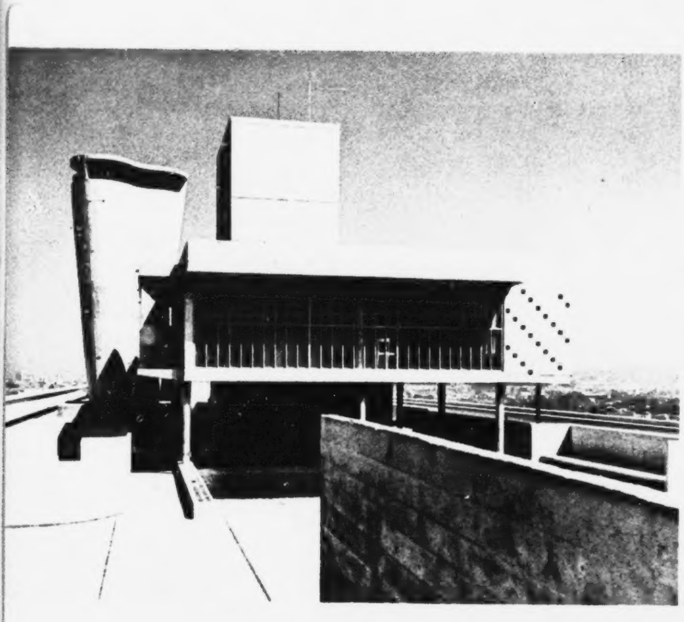
Australia has a system of grouping the building contracts on several schools within a district in one large contract, thus allowing builders and the consumer the advantages of bulk purchase.

Prefabrication and site fabrication are also being used to varying degrees in many countries. Australia has tried using prefabricated aluminum units. Belgium, after considerable research, settled upon a wooden-framed unit of compressed flax fiber held together with asbestos cement. The Soviet Union has used site fabrication by precasting large wall units of reinforced concrete and raising them into place one on top of the other, much as a child might play with building blocks.

France

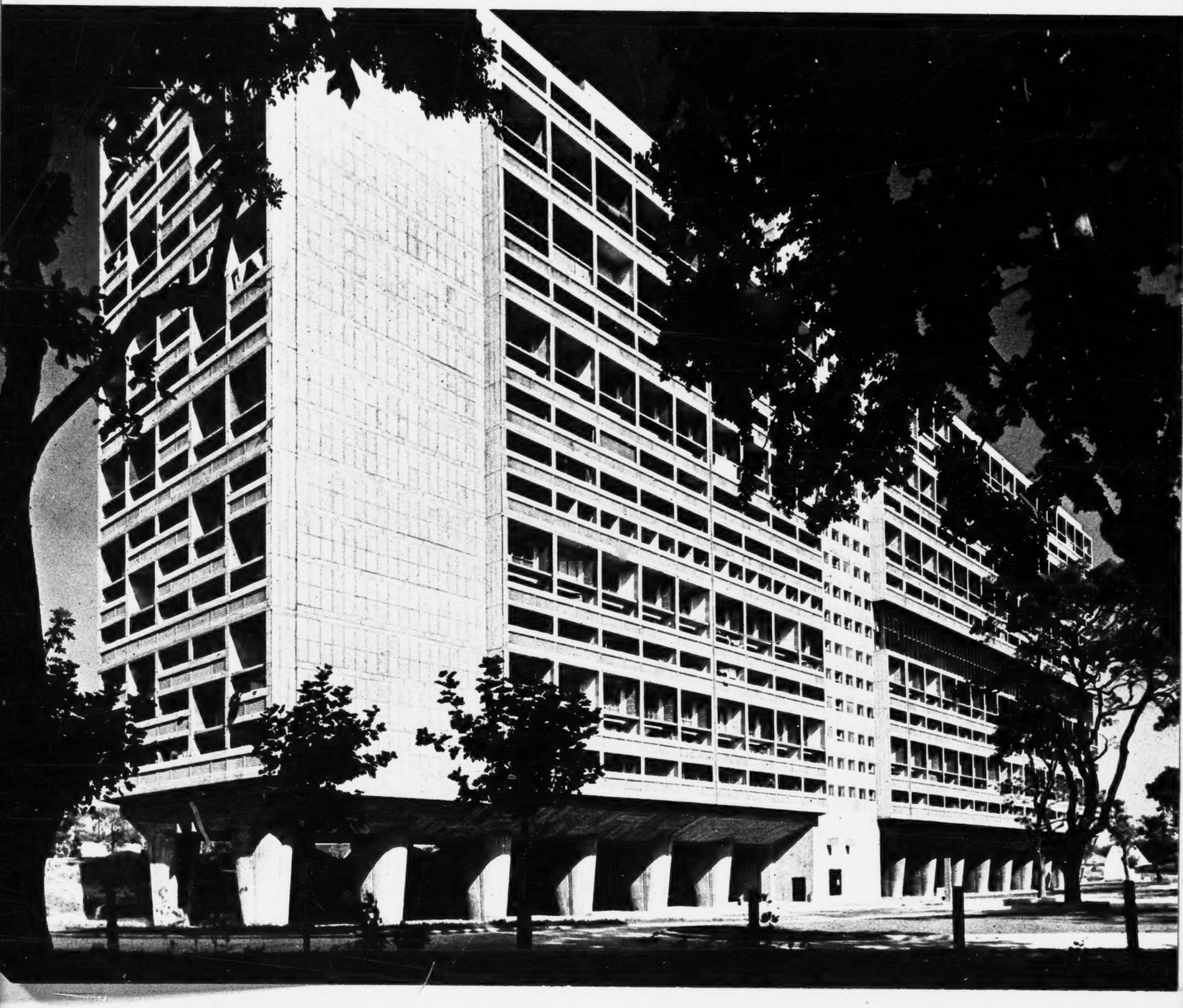
The children go up to school.

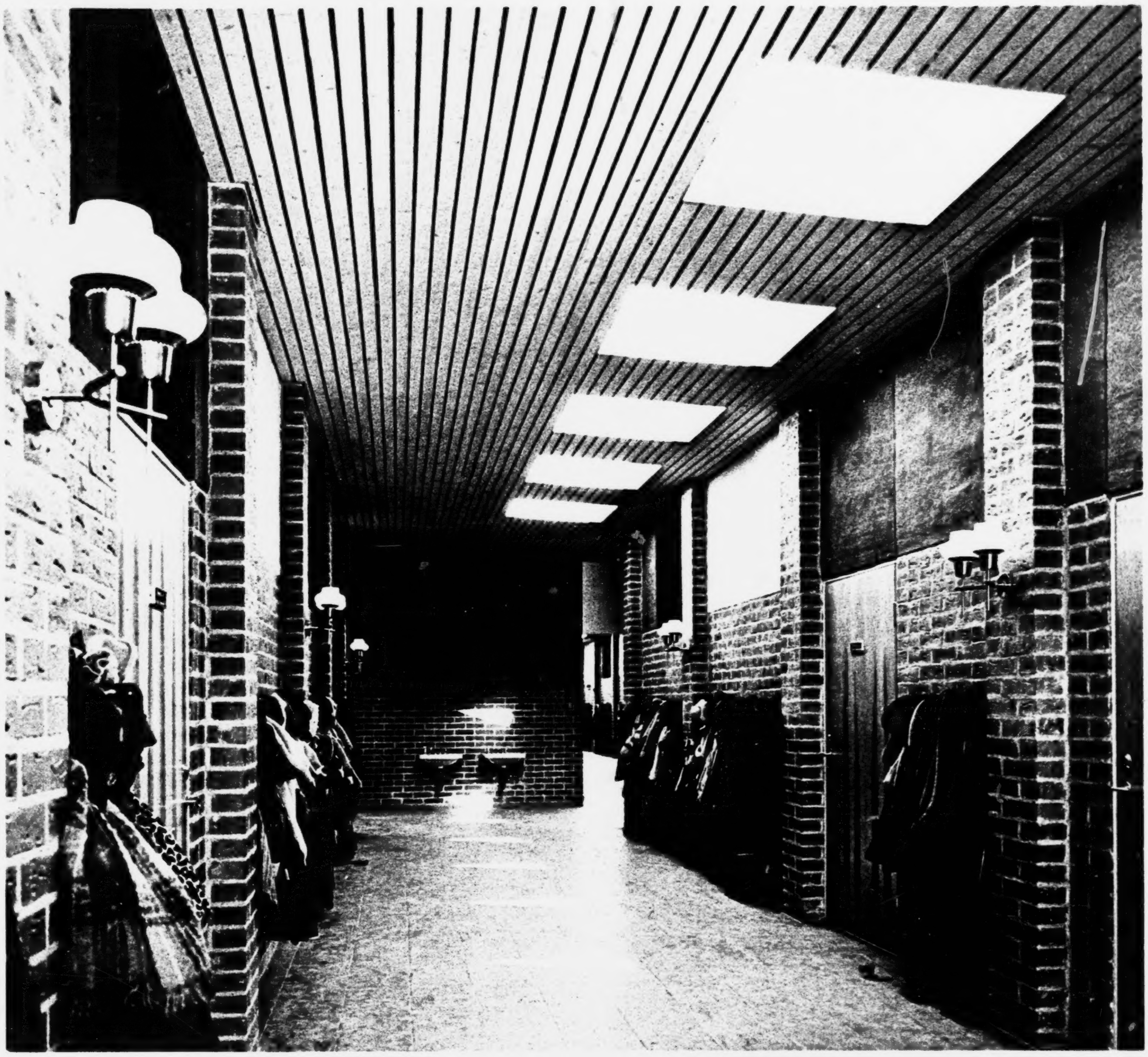




France

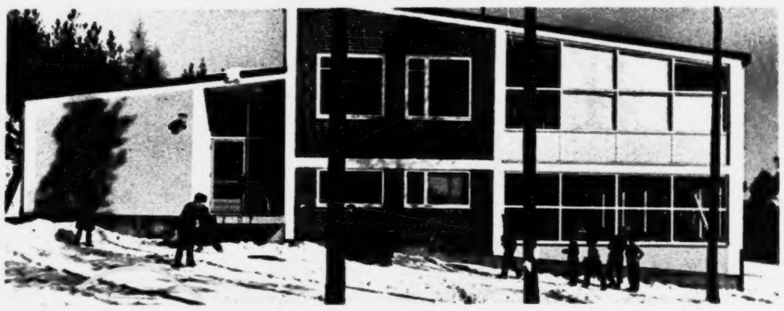
Little children stay close to home in this school on top of the apartment house where they live. Housing Development, Marseilles, France. LeCorbusier, architect.

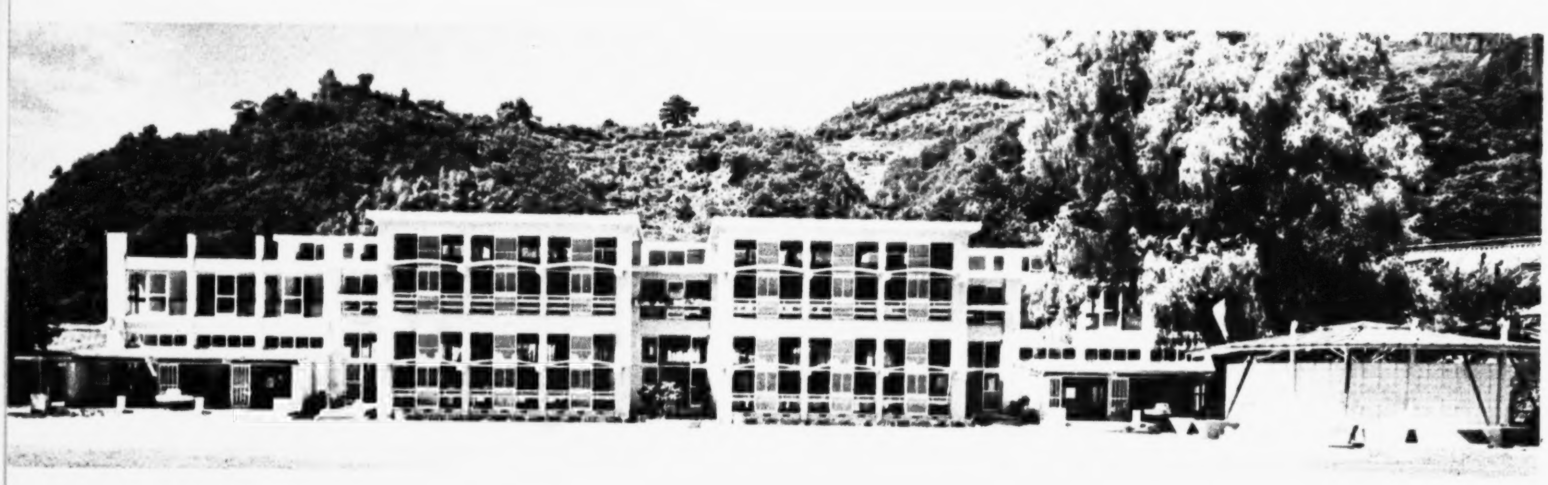




Sweden

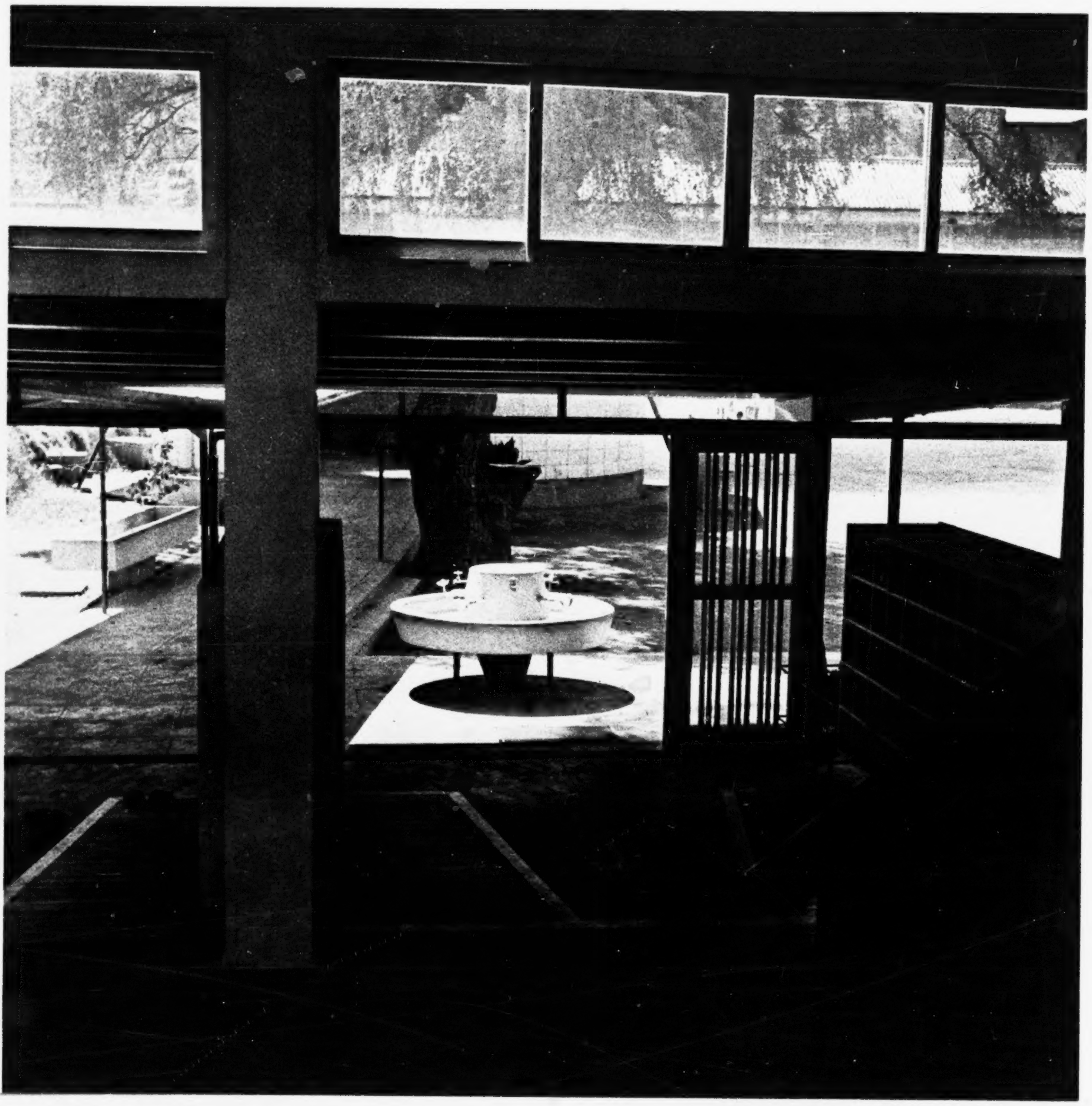
The Mölltorp School and a corridor of the school in Lidköping. Boustedt and Heineman, architects.



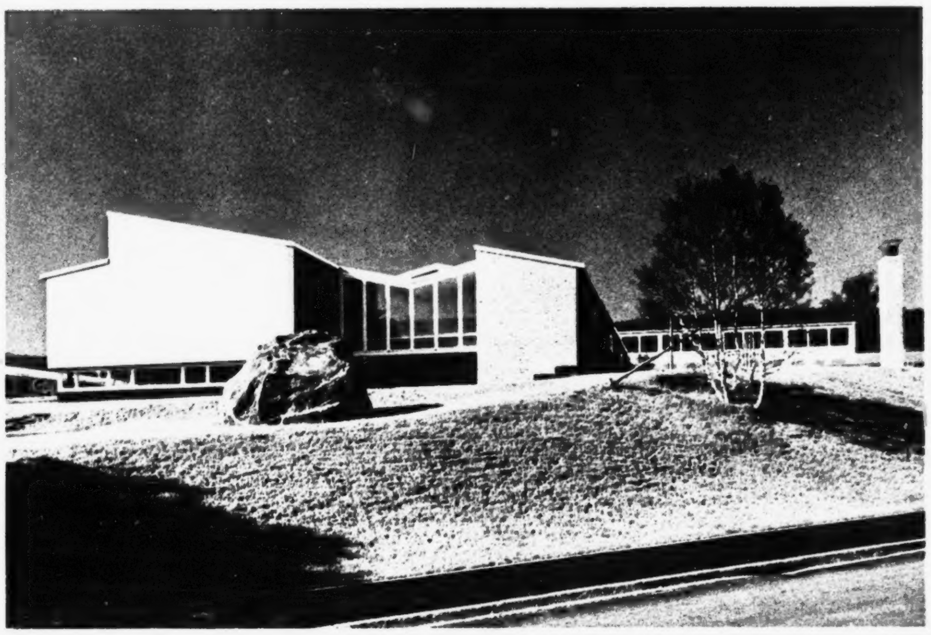


Japan

Kamiyama Elementary School. M. Matsumura, architect.



Switzerland



Typical of many
European schools,
good landscaping
and art
are integral parts
of the school.

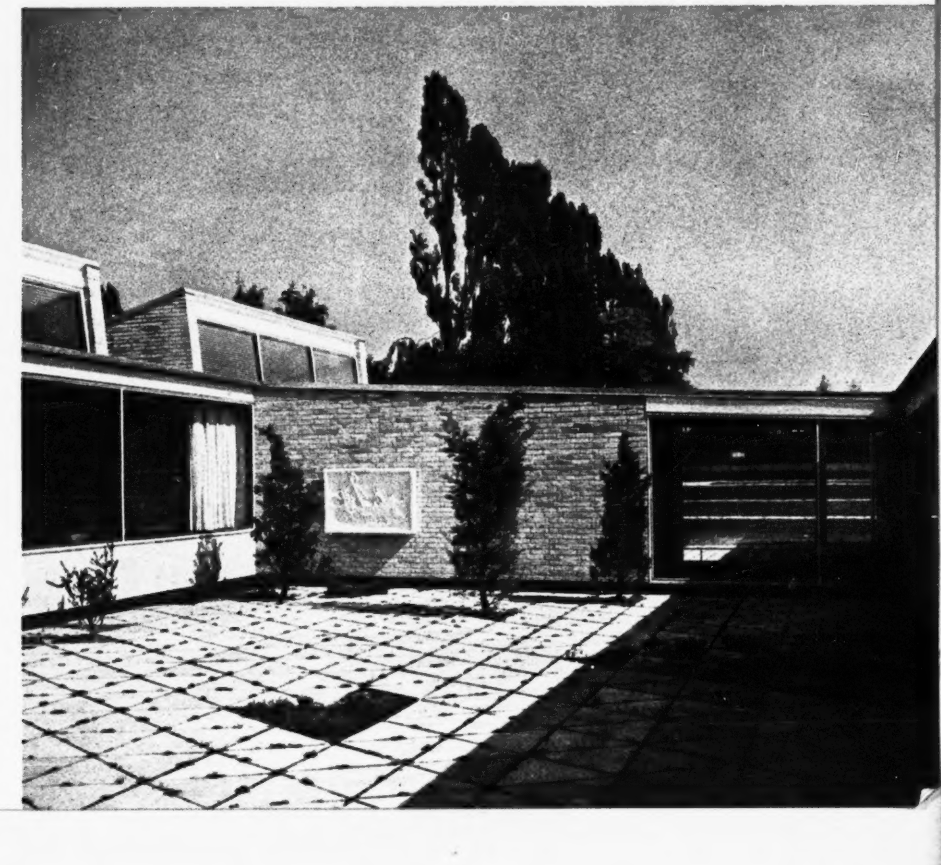
Chriesiweg Elementary School, Zurich. Cramer and Jaray and Paillard, architects.

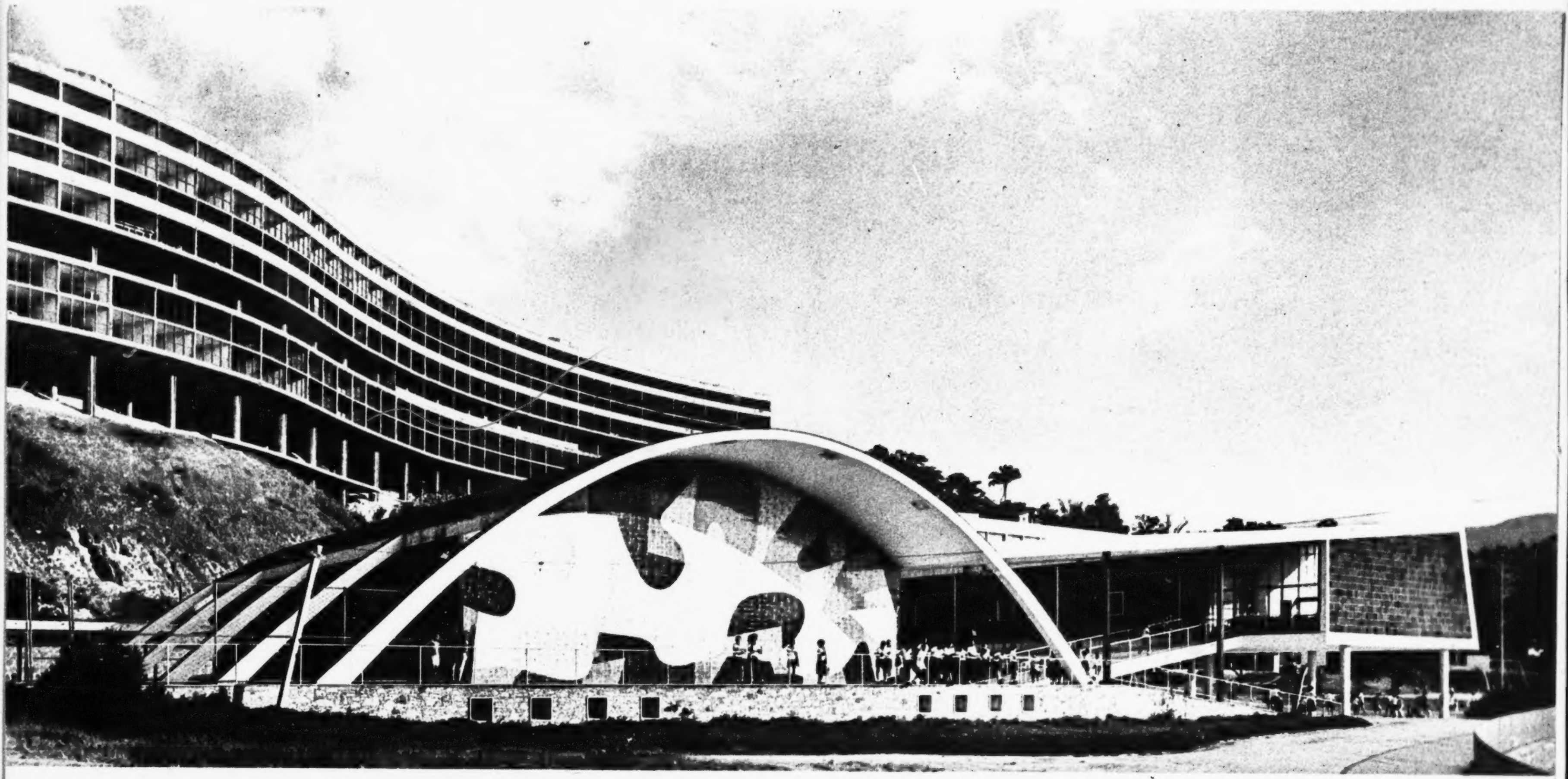
Sweden

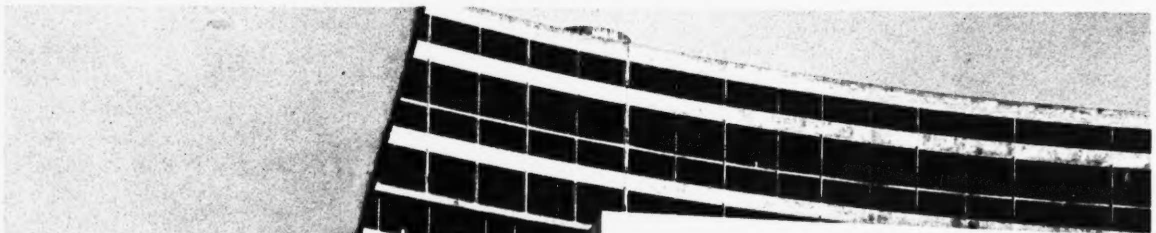
Eriksdal School, Skövde. Boustedt and Heineman, architects. Sculpture by Eric Grate.

Denmark

Munkegaard Elementary School, Gentofte. Arne Jacobsen, architect.







Brazil

Pedregulho, low cost housing project in Rio De Janeiro, has its own primary school and gymnasium. Affonso Eduardo Reidy, architect. Right, a detail of the mural by Portinari with its repeated pattern of leaping children, protected by the curving shell of the gymnasium roof.

England, through its Development Group, has attempted to establish uniform measurements—or what are called modular units of measurement—for building materials and designs. An example of the use of a modular unit is modern American kitchen equipment; almost all ranges, be they gas or electric, come in standardized widths, lengths, and depths, thereby enabling the home owner to refurbish or design a kitchen quickly and cheaply just by taking the equipment in standardized measurements and fitting it all into the space at his disposal.

A modular unit for schools can be anything from 2.2 inches to 4 feet or 16 feet or what have you. Currently the British have standardized on the 4-inch module. The important thing is that there be an arbitrary standard so that the steel framing or the exterior panels or the window sashes for the entire building can be manufactured at the same time and quickly, thus cutting down considerably on the cost of production. This makes it possible for buildings to be put together in any number of different and appropriate architectural arrangements simply by fitting the modular materials into differing patterns. It is similar to the principle of the Erector set.

What can we learn from some of the procedures and methods that other countries are using in their race to catch up with the wave upon wave of children flooding into the schools? Because of differences in expectations, in economic systems, and in cultures to be served, very few foreign developments and inventions have ready application to American schools. But some do. Certainly the lumping together of a number of otherwise scattered projects to the end that there be bulk purchase of materials should be useful. The simultaneous construction of two schools only a mile or two apart, without reference to each other as to standardized components and materials, approaches the ridiculous. But for us in America to join with our neighbors in such matters runs counter to the principle of local autonomy and political separateness, as well as to the traditional relationship of client to architect to contractor to subcontractor to supplier or to the building trades.

Probably the most useful importation we in America can make from abroad is to adopt and put into practice a standard module. The American Institute of Architects and several other important groups, professional and industrial, have long urged the adoption of modular coordination in building. Yet in 1959, only about 10 per cent of school building contracts were so specified. Modular coordination will come to school construction only when school boards demand it, architects urge it, contractors become familiar with it, and manufacturers of components are willing to retool to produce it. This, in the American way, will take time.

In our concern about schoolhousing we are not alone—throughout the world people are looking for new and better answers to the problem.

But while we are searching for answers many a schoolhouse will be planned and built. This book is an effort to help in that process, by putting the question in perspective in time and geography and by discussing the major directions of the problems: planning, building, and money.

Remember that schools will go up before we have all the answers. Robert Moses once said that in his long career in public service he never did anything right, he just did the best he could under the circumstances and moved on. So do the best you can.

YESTERDAY

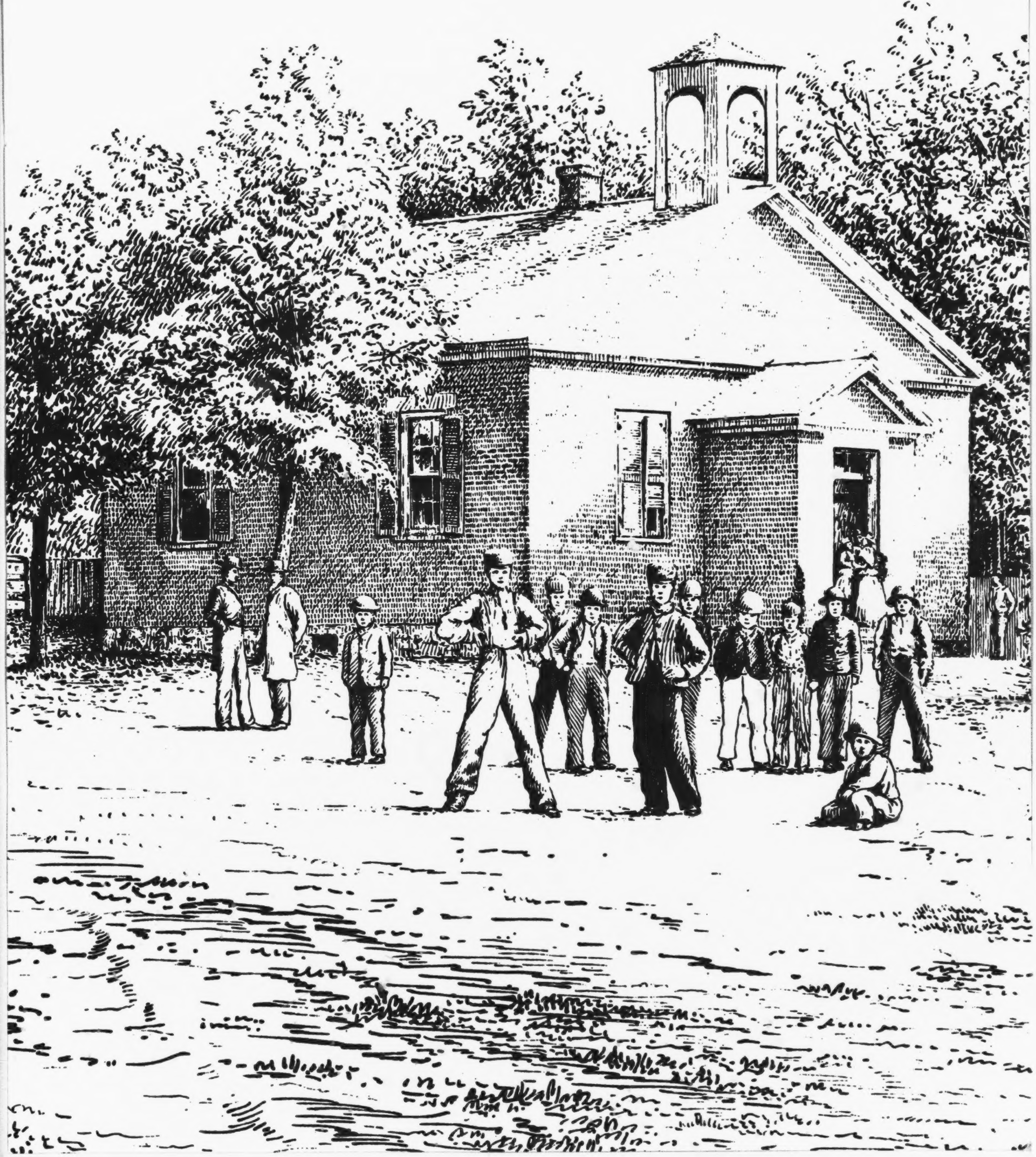
Some things appear just to *be* without having *become*. Children, for example, cannot picture their parents as ever having been anything other than what they are.

In a sense this is so with our schoolhouses. Until they began changing in the postwar period, they all seemed unchanging and unchangeable. But they aren't. To understand a schoolhouse and the elements that make up its cost and to look at its future, requires a look at its past.

If we look back we see that two historic streams merged to form today's American schoolhouse: one stems from the curriculum and method of teaching it; the other from our traditions of building and architecture.

FROM EDUCATION TO ARCHITECTURE

During the early years of the nineteenth century the most typical school in the United States was the rural one-room schoolhouse, with its teacher attempting to be all things to all children. Instruction was basically individualized; the teacher worked with students one by one and was chiefly engaged in hearing recitations, testing memory, and keeping order. Class lectures or discussion were virtually unknown. Often the schoolmaster's home was used as a schoolroom, and such regular schoolhouses as did exist were dirty, noisy, and ill-suited to school purposes. These were the days of only the three R's and heavy emphasis upon moral teaching through the reading of the Bible and by way of such works as John Cotton's *Spiritual Milk for Babes Drawn*

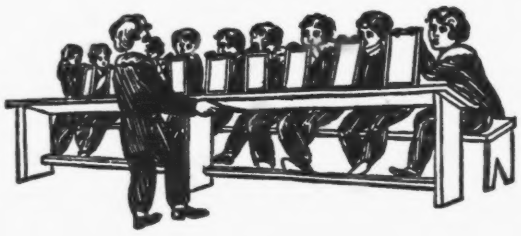


Out of the Breasts of Both Testaments or the *New England Primer,* which in one fell swoop taught reading and religion with verse such as:

> *I in the Burying Place may see*
> *Graves shorter there than I;*
> *From Death's Arrest no Age is free,*
> *Young Children too may die;*
>
> *My God, may such an awful sight,*
> *Awakening be to me!*
> *Oh! that by early Grace I might*
> *For Death prepared be.*

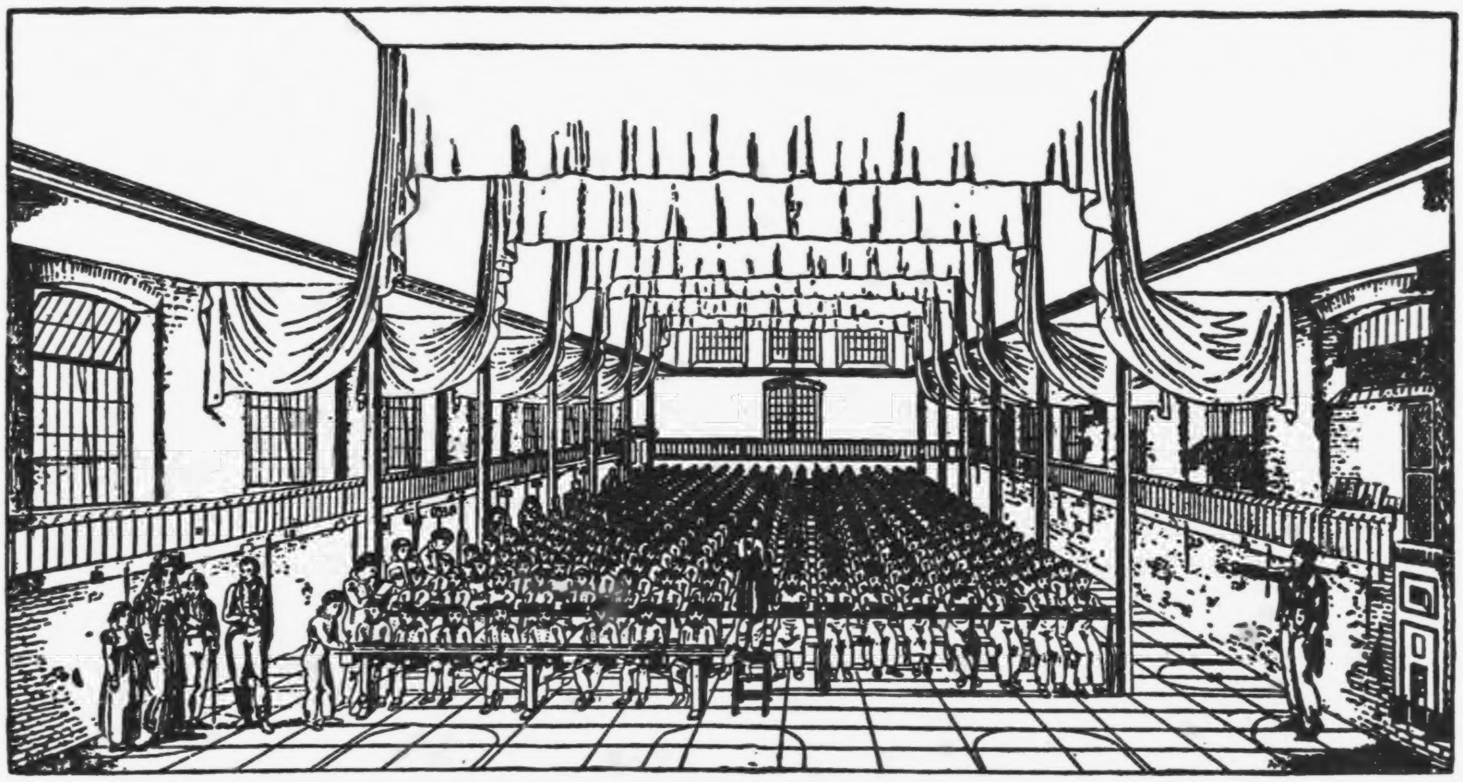
As America changed, so too did the schools, keeping step with the development from an agricultural economy to an industrial, urbanized society. Great new inventions, new means of manufacture, transportation, and communication altered the face of the land. Cities grew up where none had been. The change in population density and in the way of life of the people led to the development of new kinds of schools, differing in organization, size, setting, and pedagogical theory. The nature of these schools as they evolved during 150 years is a basic factor in the decisions we make today regarding a school building. School buildings have not always been the same. They have changed in accordance with our educational ideas, and they have changed because of what we have been willing and able to build.

The Lancastrian school monitor, having given the command to "show slates," inspects written work.

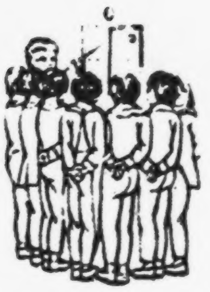


If we turn the clock back a century and a half, 1806 to be exact, we see the Lancastrian school system of England making its debut in America. This system took the catechism as its model. Each subject was reduced to a set of questions and answers. The teacher drilled a group of 50 head pupils, or monitors, who in turn drilled 10 pupils. Thus one teacher was enabled to teach 500 students. Obviously, to work well this system required strict organization and a robot-like conformity. The management of the class, the classification of the students into rows by age and achievement, the details of recitation, and the use of apparatus were minutely prescribed. Deviation was outlawed. Discipline of an almost military character was rigidly enforced. This was an era

A Lancastrian schoolroom

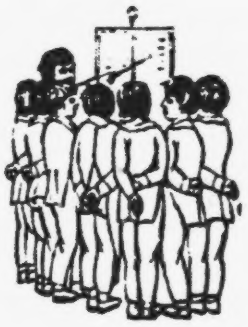


still largely influenced by the puritanical views of Jonathan Edwards, who at an earlier date had warned, "As innocent as children may seem to us, yet, . . . they are not so in the sight of God, and are infinitely more hateful than vipers." The Reverend George Whitfield, at about the same time, had pointed out the resemblance between children and rattlesnakes, "which," he said, "are likewise beautiful when small."



To be sure, the cost of this primitive type of education was low. In 1822 it was $1.22 per pupil in New York City for the entire year. It was also economical of space—a room 50 by 100 feet, with rows of benches and room around the edges for the groups of 10 pupils and their monitors, could accommodate the 500 students with only 10 square feet per pupil.

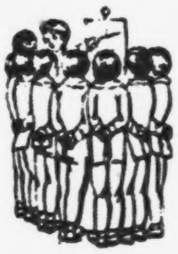
The Lancastrian schools spread quickly and disappeared almost as fast. By 1840 they had become a thing of the past. But the system had made a lasting mark for which it deserves to be remembered. Until then, education had been a slow, expensive process because it had been carried out on an individual basis or in very small groups. By establishing the principle of group instruction at a low cost, and by orienting people towards the idea of education for the many rather than the few, Lancaster's schools paved the way for free, public, tax-supported schools as we know them today.



The free, graded school, however, did not arrive overnight. It had to go through a step by step process of evolution. An important step was the unification of the separate reading and writing schools which functioned independently of each other though situated in the same building. The separate schools were autonomous units: the teacher in each school was the ruler of his own kingdom. This domain consisted of a large classroom with a smaller, satellite room attached to the side of it. The master would divide the work with an assistant and, while he was instructing the group, his assistant would hear individual recitations in the smaller annex to the main room.

After unification of these separate schools, the final step was sorting and grouping the children by age into seven, eight, or nine grades with a separate teacher for each grade and a system of promotion from one grade to the next with a corresponding progression of subject matter.

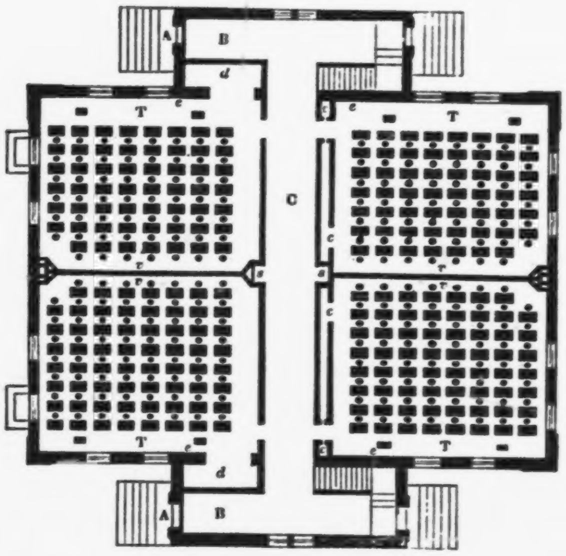
This ultimate organizational step came about naturally, since for some time the course of instruction had been in the process of expansion, with such subjects as history, geography, grammar, composition, and even bookkeeping added to it. Moreover, textbooks were by now in common use, the school term had been lengthened, and the years of school had already been increased. (To be sure, the graded school was a child of the cities. Rural areas continued for many years to lump all their young hopefuls together in one ungraded collection. In many parts of rural America this practice goes on today.)



The Graded Elementary School The graded, public school called for a different architectural approach. An entirely new kind of schoolhouse architecture was worked out to meet the needs of the first fully graded, public school in the United States. This was the Quincy Grammar School built in Boston in 1848 and still in use. Ellwood P. Cubberley, noted education historian, has this to say of it:

> *This building formed a new architectural type which was extensively copied, in Boston and elsewhere, and this new building, with its twelve classrooms, assembly hall, and a principal's office, was thought*

> *by many to represent such an advance that little improvement would ever be made on it. For the next fifty years it was the standard type of elementary school building erected in our cities. . . . This was in large part due to the fact that this type of building was so well adapted to a drill-and-content type of course of study, which from about 1850 to about 1900 was the dominant one.*

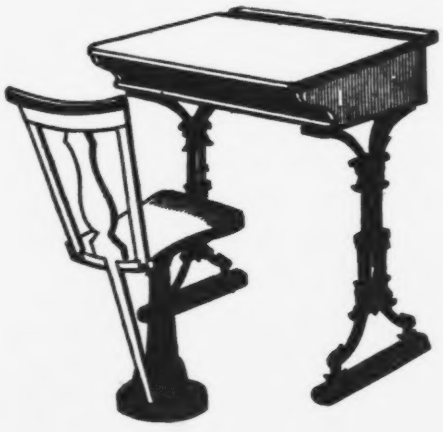


What did Quincy Grammar School look like?

It had four stories, the first elementary school of such a height, with a basement and an attic. The fourth floor was entirely given over to an assembly hall large enough to seat, in pewlike benches, the entire population of the school. (The building accommodated 660 students.) The remaining three floors were divided up into a series of separate, equal-sized classrooms with a clothes room attached to each. Each classroom was 31 by 26 feet into which were crammed 55 pupils—less than 15 square feet per child. The classrooms featured a great innovation; they had, bolted to the floor, a separate desk and chair for each pupil—seven rows of them, eight to a row. These were a vast improvement over the benches which had been accepted for the one-room school in the early nineteenth century, and they were ideally suited to their function at that time. The pupil was to sit passively and listen to the instructor or watch him write at the blackboards which covered the better part of three sides of the room. Occasionally the student would rise to his feet and recite what he had heard or read.

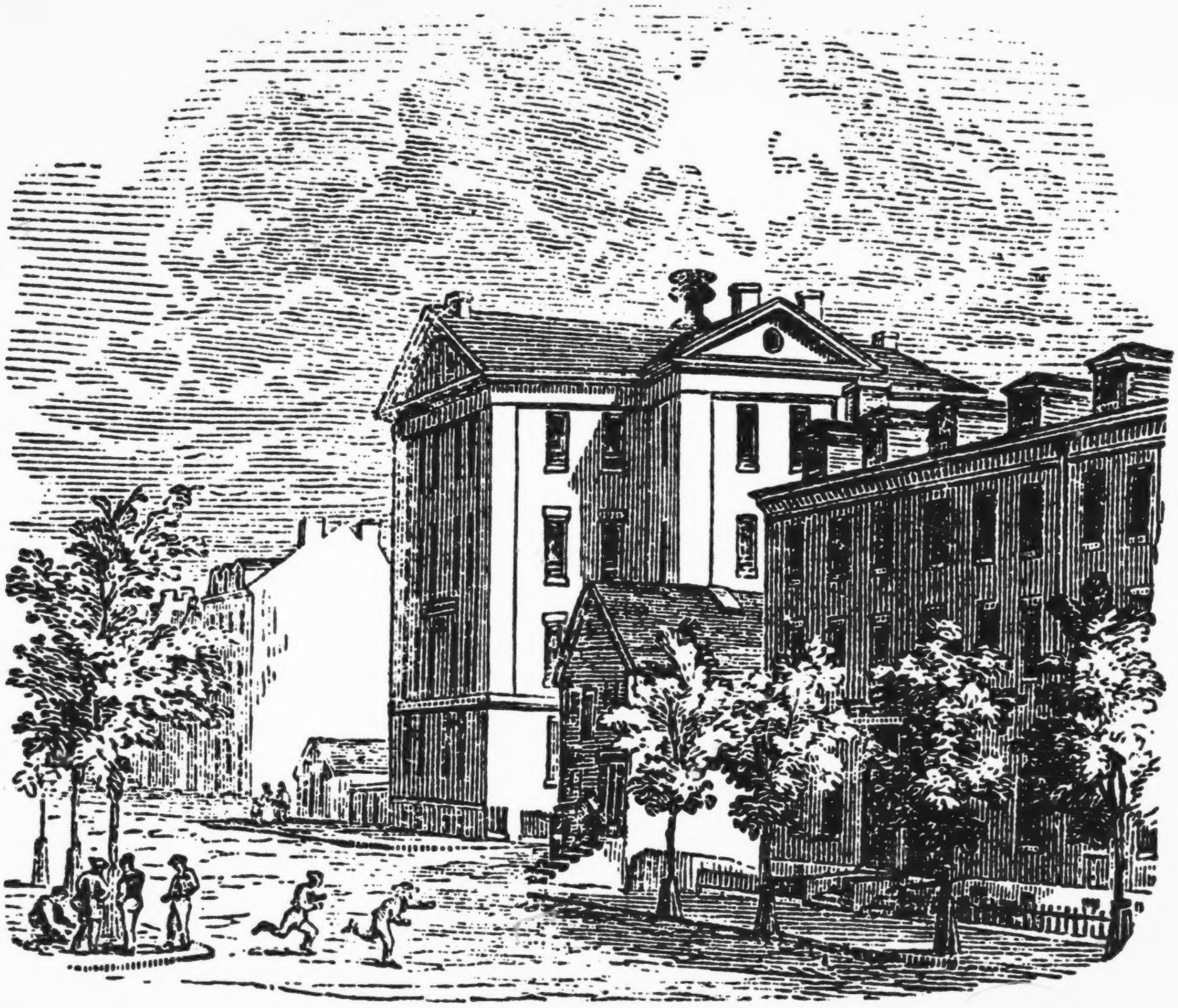
And so was born the prototype of the schoolhouse which, modified by progressive education, the kindergarten, and the introduction of manual training, was carried into the twentieth century. Those of us raised in the cities even in the past few decades are painfully familiar when its dark, gloomy, forbidding façade.

The turn of the century brought with it the beginnings of a reaction against regimented instruction. From about 1890 to the 1920's the size of the class was reduced to 40, 35, or 30 children. The change was influenced by a number of factors—the falling birth rate, the slowdown in population growth, and the rise in church-related school enrollments. But basically it sprang from public acceptance of changed educational outlooks and standards, which had come in turn from new knowledge of child growth and recognition of individual differences.



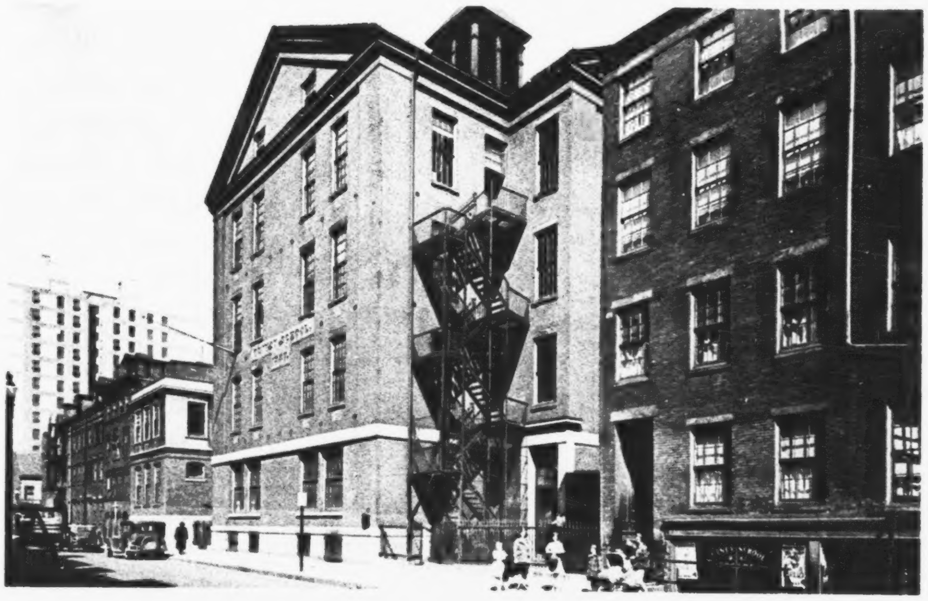
The germination of the ideas spread by Pestalozzi, John Dewey, and William James, had stimulated a freer approach to education, entirely redirecting the elementary schooling of children. The concept of the pupil as the passive recipient, the sponge soaking up information in preparation for adult life, was discarded. The broader concept of education as an integral part of the life process, of learning by doing through creative participation, slowly replaced the older theory.

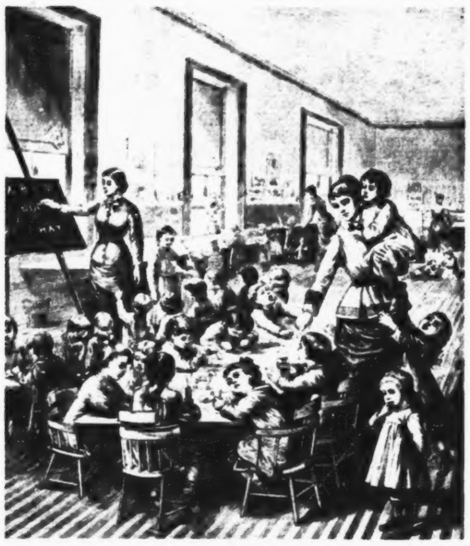
Observation and investigation now took the place of memorization. Discussion, evaluation, and self-expression superseded the mere regurgitation of facts. This opened the doors to new subject matter. Observation led to the study of elementary science and home geography; discussion developed an interest in the study of language usage as distinct from formal grammar; counting and measuring led to a whole new study of numbers and primary arithmetic. The multiplicity of subjects and of activities of the youngsters involved led to breaking the class into small groups for part of each day. One group might be



Tyler street.
Established, 1847. } **QUINCY SCHOOL.** { Erected, 1847.
Cost, $60,210.18.

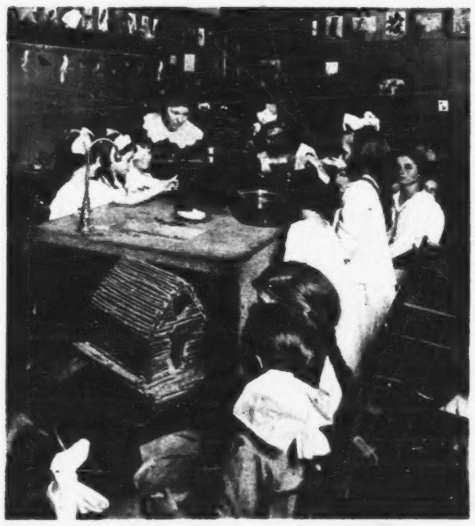
Quincy School, Boston, first American public school in which children were arranged by grades. The first floor plan is shown at the left. The assembly hall "for devotional services and other general exercises" was on the fourth floor. The scholars' desks and chairs—also shown—were a great step forward. They came in seven sizes to fit the scholars and were "screwed immovably" to the floor. The Quincy School, over a century after it was built, is still in use.





The introduction of the kindergarten made for larger rooms and more flexibility in furnishings and program

. . . and so did John Dewey's ideas of learning by observation and by doing rather than by rote.



carrying out their study of home geography by building a model of their city out of wooden blocks; another, concerned with arithmetic, might set up a small shop to sell supplies to the "city builders" in exchange for homemade units of currency, thereby having direct experience with adding, counting, and subtracting. Still another group, as part of their science study, might grow plants native to their geographic location—or even keep small animals. Such varied and mobile activities made a great demand on space. Not only was more space needed, it was necessary to have movable furnishings as well to allow for changing activities during the day. In addition, there was now a need for new kinds of storage facilities to house the many varieties of materials used by the children.

We must not overlook the influence of the kindergarten on the advent of larger rooms and greater flexibility in program and furnishings. The first public kindergarten in our country was opened in St. Louis in 1873. It was alien to the existing school system. Its emphasis was on the individuality of the child, on the unfolding of his unique personality, and on his ability to function effectively as a social creature in relation to other children. It encouraged children to build, work, and play together. Music, art, dancing, and other forms of creative expression were used to release native talents and energies. (These were the beginnings that years later provided material for the cartoons lampooning this more indulgent approach to childhood, which would typically show a puzzled parent viewing a report card with the legend, "A in Sandpile.")

The trend was irreversible. Rooms had to become bigger. Furniture had to be unbolted from the floor. Open shelves and new storage space for paste pots, scissors, clay, paint, and building materials had to be supplied. Some rooms had sinks installed in them so a ready water supply would be available for science experiments and art work.

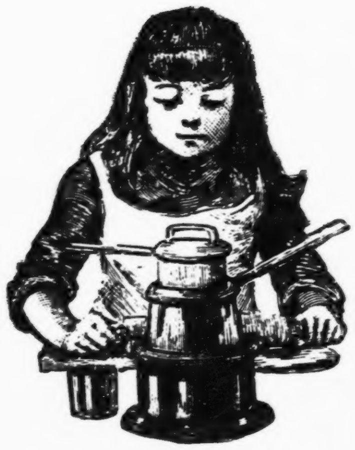
Another innovation, which came to us this time from Finland and Sweden via the Philadelphia Centennial Exposition of 1876, was manual training, then called sloyd. Metalwork and woodwork objects, turned out by foreign students and displayed at the Exposition, were highly praised by the then president of the Massachusetts Institute of Technology. In 1878 the first manual training school was opened in St. Louis, and eventually manual training courses were incorporated into the curriculum of the upper elementary grades. For girls it was in the form of needlework, weaving, and the home arts; for boys it was wood- and metalwork. The point was that youngsters would develop a respect for the dignity of labor and the usefulness of objects, and would have, in addition, the experience of doing their own work from start to finish.

By the early 1900's the elementary school with kindergarten rooms, rows and tiers of uniform classrooms, assembly halls, and shops had been fashioned. The trend toward additional space per pupil and additional facilities continued into this century. At the turn of the century the total space per pupil normally ranged from 40 to 80 square feet. By 1940 the range was 80 to 100 square feet per pupil, and in the postwar period the range was from 80 to 130 square feet.

The Secondary School Meanwhile, in the secondary school, even more revolutionary changes were going on. Its status as a legal part of the tax-supported, public school system had been established by the Kalamazoo Decision back in 1874. The high school had become an extension of the elementary school, providing a ladder on which all children could move from the ABC's at the bottom way up to a high school diploma—an indigenous American creation whereby an education became available for all youngsters regardless of economic class or social background. While in the 1860's there were only some 300 high schools reported to be in existence, by the turn of the century their number had increased to over 6000. Public pressure for more education for more people, combined with humanitarian and labor union opposition to child labor, steadily increased the proportion of young people attending secondary schools. In the period from 1899 to 1920 enrollments doubled every decade. At the same time, the average I.Q. of high school students dropped from 115 to just over 100.

In 1910 the junior high school appeared on the scene to help children make the transition from the less formal atmosphere of the elementary school to the more formal environs of the high school. Here, too, they were to be provided with opportunities to explore their interests and aptitudes before deciding on the kind of high school they would go to.

By now the high schools were having to meet the needs of great numbers of young people with a very wide range of abilities and interests, and they began by offering watered-down college preparatory work, some shop work, and a few clerical courses. Later the states, and in 1917 the federal government, encouraged vocational training programs. Commercial education grew in importance. All these programs took more and more space and equipment—typing and shorthand rooms, accounting rooms, office machine laboratories, and shops for automobile mechanics, metalwork, machine tools, printing, and carpentry.



Manual Training—woodworking for boys, the domestic arts for girls, called for more space in the school.

While some of the large city school systems split up the high school by functions, college preparatory, commercial, vocational, or technical, most smaller communities held them all together in one school which came to be known as the comprehensive high school, a peculiarly American institution. The students were sorted and placed on tracks—college preparatory, vocational, or commercial. Guidance counselors were added to aid in the sorting, to help students choose appropriate courses and eventually careers, and to help counteract the growing impersonality of the high school. Offices, guidance centers, and conference rooms were added.

Other subject areas—music, physical education, and science—were to add further to the secondary space requirements.

Vocal music was recognized as a school subject early in the nineteenth century. Instrumental music had to wait until about 1900 to be given recognition as an extracurricular subject. Improbably enough, it was via the first World War that music really found a place for itself in the schools. Edwin Birge, music education historian, writes:

> *The effect of the World War (I) upon music in the public schools was beyond calculation . . . . fundamental importance (was) given to music in winning the war. The value of music was brought home to the people . . . with all the force of governmental sanction. . . . Organized singing in the camps and community singing at home became a daily experience . . . . no less significant was the enormous prestige given to band music. Bands were needed for every training camp and for every regiment . . . moreover the military training*

> *introduced into the high schools of necessity required a band for every school. . . . We became, for a time at least, a singing nation welded together by the unifying power of music. The . . . effect educationally was an unqualified acceptance of music as a major subject on the part of both school authorities and the taxpayers of the nation.*

Perhaps Birge overemphasized the importance of the war and the immediacy of its effect, but in 1927, at a superintendents' conference of the National Education Association, a resolution was passed which read, ". . . we favor the inclusion of music in the curriculum . . . on an equality with the other basic subjects . . . we believe an adequate program of high school music instruction should include credit, equivalent to that given to other basic subjects. . ." The addition of instrumental music as a regular subject meant additional specialized space in the school.

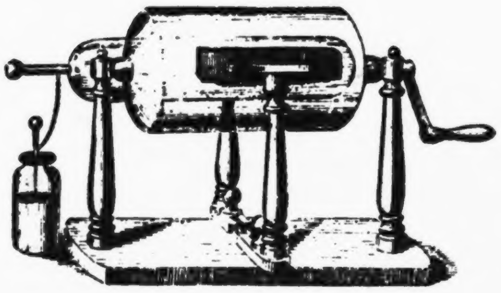
Major credit must be given the Germans, who immigrated in great waves in 1848, for the introduction of physical education into the school system. Emphasis was on gymnastics, not games, and these activities at first took place in school corridors, basements, and attics. While a few college gyms were built earlier (Harvard had built the first in 1820), it was not until after the Civil War that the physical education program really began to develop. The colleges began building gyms, Dartmouth in 1867 and then Princeton (theirs was very advanced with eight long bathtubs lined with zinc), and gradually the secondary schools followed the colleges' leadership.

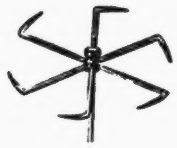
The first World War again provided the impetus for educational innovation. The fact that one-third of the men drafted for service were rejected as unfit gave rise to great public concern about physical fitness. As a result, greatly expanded facilities—swimming pools, spacious gyms, and large athletic fields—sprang up across the country. Sports, particularly basketball and football, became increasingly popular, replacing the gymnastics which had been the backbone of physical education. This was also the period when the question of granting school credit for physical education classwork was seriously fought out. (In 1924 one school official, opposed to it, said: "It would be as much out of the general scheme as giving credit for eating well-balanced dinners.") The movement for recognition was too far under way to be defeated, however, and by 1930 over a third of the states were granting credit.

While physical education came under attack in the 1930's as an educational frill, World War II, and the fact that more men were rejected for military service than were accepted during World War I, again brought intensive concern with physical fitness. To a lesser extent, so did the Korean War. Consequently we have gyms, locker rooms, showers, and the allied space allotments for physical education that are taken for granted today.

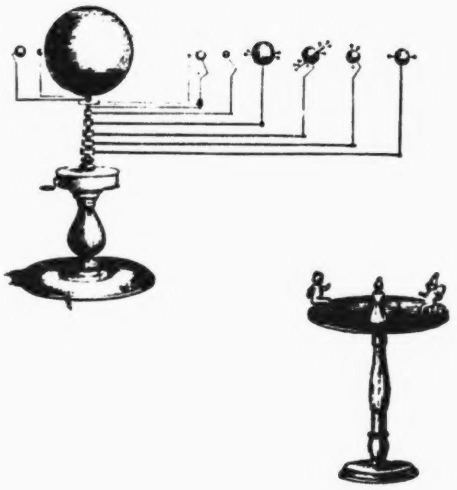
Science equipment was in common use in the early nineteenth century, though it was then called philosophical apparatus. Nevertheless, regular secondary school laboratories did not come until a later date under the impact of college requirements. Harvard, in 1872, accepted physics as a subject for admission and, because of the lack of standardization in the secondary schools, proceeded to dictate in detail the nature of science instruction which would be accepted. Among these requirements were a specified amount of laboratory work to be done each week and evidence of such work in the form of written records.

While the early nineteenth century lab work, such as it was, had dealt with plant and animal morphology (later on botany and zoology were combined and taught as biology), the purposes of science teaching were primarily religious and descriptive. From 1870 on, when the laboratory method really came into use, the religious objective gradually disappeared and the dominant objective of science teaching became the development of the faculties of reasoning and observation. The laboratory manual was developed to aid in the efficiency of instruction, and science education became a formal, highly systematized affair. Elaborate and complete labs were provided for secondary schools.





General science came into the schools about 1910, finding a foothold in the junior high, where it was incorporated into the curriculum to serve two purposes—as interpretation of environment and as pre-high school exploration of the sciences. Chemistry was first reported as a subject in the secondary schools by the U. S. Office of Education in 1900. Fundamentals of electricity, aeronautics, and conservation were first listed as academic rather than vocational courses in 1949. With the recent overwhelming advances in science, scientific instruction must become a necessary part of the education of all youngsters, not just a speciality for the few who choose it. This has been and will be an emphasis that contributes to the size and cost of the secondary school.



As the years have moved on and the schools have had to increase their subject matter offerings to keep pace with the quickly changing developments of modern life, so, too, a broadened concept of the school's total role in the community has evolved.

No one questioned the old Latin adage we all learned in high school that a sound mind requires a sound body, but no one did anything about it for a long time. It took a series of dangerous epidemics to bring about the employment of the first school nurse in the United States, in New York City in 1902. Her job was to inspect the children each day. But what had started out merely as an effort to detect and control contagious disease developed into a program of tests for eyesight, hearing, and hidden physical defects. By 1911 there were 415 school nurses at work in almost as many cities. This recognition that communities wanted their schools to be partially responsible for the physical well being of the child meant new spaces in school buildings for health suites where physicians and nurses could carry on their work. Today, in many schools these health suites include dental clinics.

The community service concept of the schools has made them available not just for learning, but for recreation as well. The places where school buildings stand have grown bigger. The old schoolyard with the tall wire gate around it has been opened up. It was literally opened back in the early part of the century, when the playground movement got under way, by unlocking the gates and permitting the children to play during after-school hours. In time this expanded to include organized vacation programs with areas for gardening and playing fields. (Classrooms themselves have opened up, and in many places where school courses are offered 12 months a year, classes are conducted out of doors.) So the old paved schoolyard of yesteryear

School sites have opened up . . . Syosset High School, Syosset, Long Island, Eggers and Higgins, architects.

has now become almost a small park—five acres for an elementary school and ten acres for a high school have come to be considered minimal site standards.

School buildings no longer stand idle after three o'clock. They serve as centers for adult activities of all kinds—adult education classes, amateur theatricals, civic affairs, and community meetings. More and more they are called upon to supply the needs of an adult population with greater leisure time and the desire for group recreation and part-time education.

FROM ARCHITECTURE TO EDUCATION

These developments in program and teaching methods were not the only forces affecting the American schoolhouse. Traditions and technology of building and architecture, as well as American standards of design in all fields, were undergoing basic changes.

Historically the school was not architecture, at least not notable architecture. The important architectural buildings for education were colleges and universities. Talbot Hamlin's monumental *Architecture Through the Ages* refers in passing but four times to schools. Sigfried Giedeon's *Space, Time and Architecture* acknowledges the existence of no primary or secondary school. Hugh Morrison's *Early American Architecture* mentions the school wing of Lee's house, Stratford, and the early "Boston Latin" of which we have no architectural records.

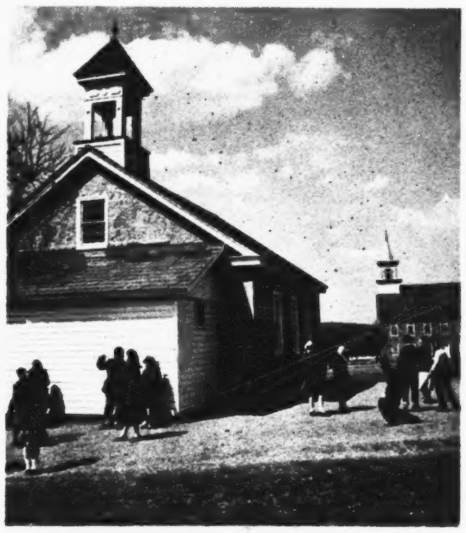
If we turn back the clock possibly we can see why. The lonely one-room school with its bell in a truncated steeple acknowledging the traditional affinity of church and school—even though legally separated—is a pleasant sentimental picture. But if we wipe away the cobwebs from our vision and look at the schools of 1848 with contemporary eyes, the picture changes. In Henry Barnard's *School Architecture* (characteristically written by an educator not an architect), he quotes the following, not atypical, report on the schools of New York State.

> *. . . 544 out of 9368 . . . visited, contained more than one room; 7,313 were destitute of any suitable play-ground; nearly six thousand were unfurnished with convenient seats and desks; nearly eight thousand destitute of the proper facilities for ventilation; and upwards of six thousand without a privy of any sort; . . . And it is in these miserable abodes of accumulated dirt and filth, deprived of wholesome air, or exposed without adequate protection to the assaults of the elements, with no facilities for necessary exercise or relaxation, no convenience for prosecuting their studies; crowded together on benches not admitting of a moment's rest in any position, and debarred the possibility of yielding to the ordinary calls of nature without violent inroads upon modesty and shame; that upwards of two hundred thousand children, scattered over various parts of the State, are compelled to spend an average period of eight months during each year of their pupilage!*

This is not the stuff from which architectural history is made. The influence of Henry Barnard and Horace Mann, among others, led to generally improved schoolhousing and equipment.

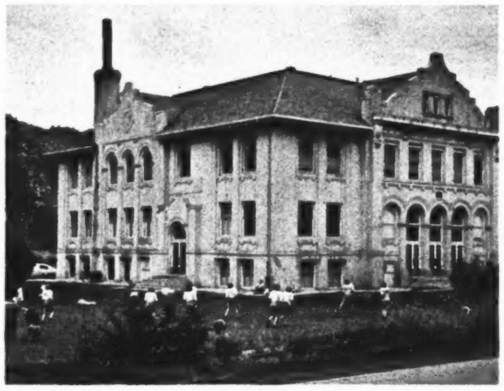
The one-room school continues unchanged in many ways, its improvements evolutionary both in space and in pedagogical techniques.

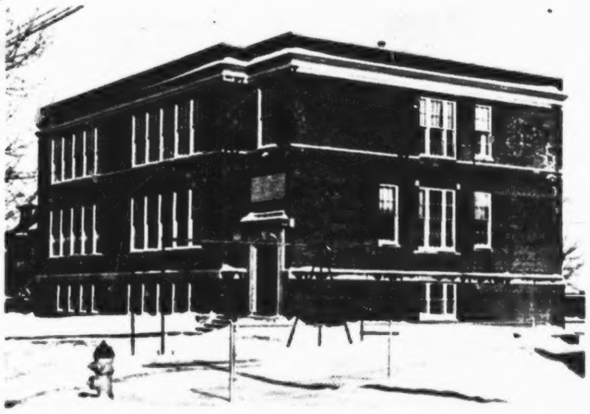
The one room schoolhouse—often better to look at than to learn in.



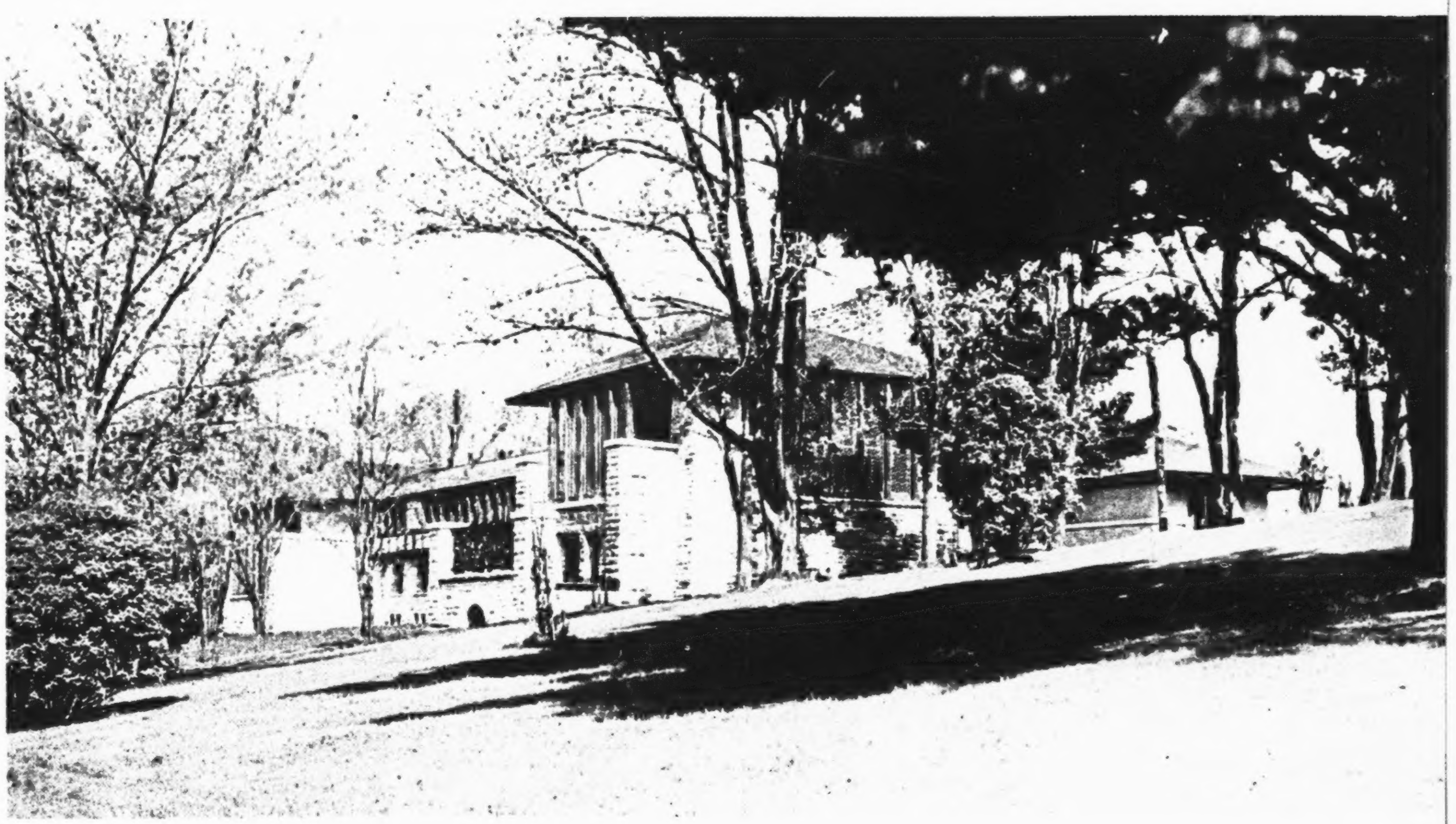
Even today one-fifth of our elementary schools are one-teacher schools.

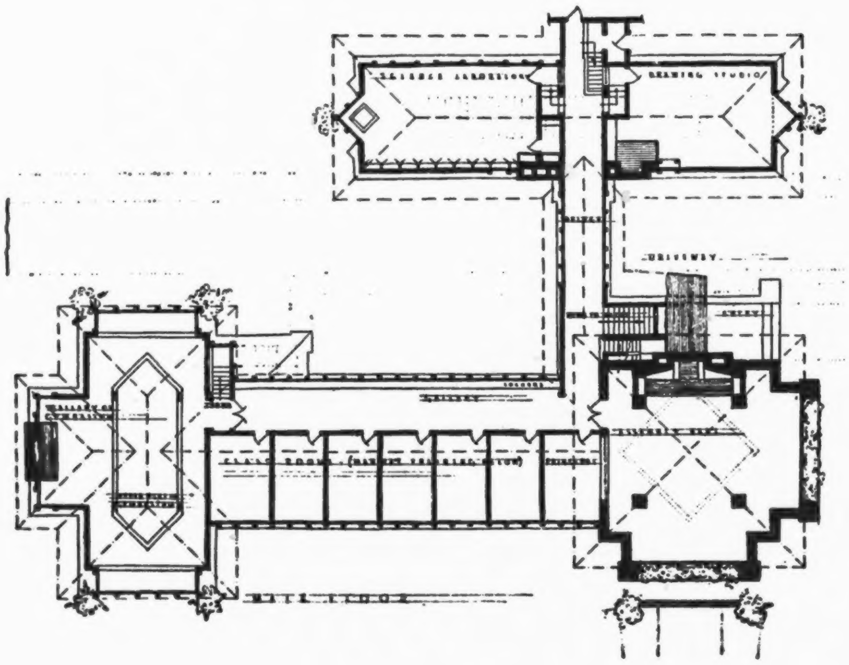
But with the rise of nineteenth century industrialism, the characteristic school became the imposing buildings which, adorned in the fashionable, ephemeral tastes of the period following the Civil War, became standard for America until the end of the 1930's. Whether their faces, applied like icing to a cake, were Gothic or Spanish colonial, Greek revival or Victorian, they were essentially a series of one-room schools, stacked up for two or three stories, to which a cavernous gymnasium and auditorium were often added along with a few other specialized spaces. Despite local autonomy in school matters these buildings are startling in their nationwide similarity. Improvements in such schools were substantial during the early twentieth century, particularly in health and safety factors. Heating, lighting, toilet facilities, eating facilities, space per pupil, and fire safety advanced considerably, but architecture stood still. In the 1930's and early 1940's the historical gingerbread often disappeared leaving a brick box with holes for windows in a style which can be described only as neuter.





A schoolhouse could be ordered in any historical style, and sometimes in indescribable styles . . . occasionally the spirit ran out and the community was left with nothing but a brick box with holes in it.

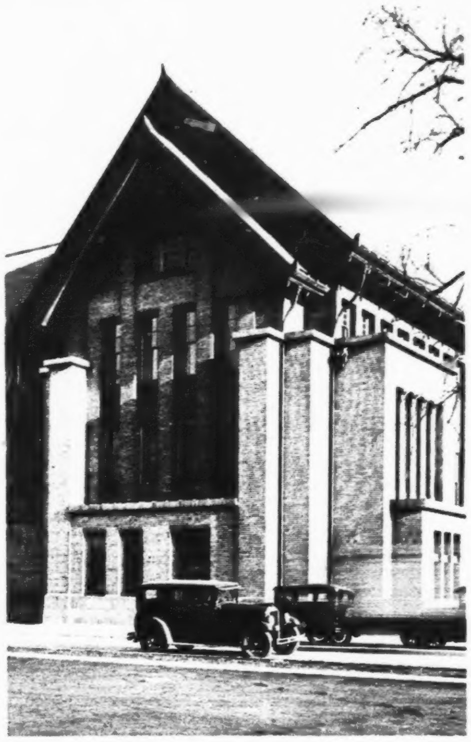



DRAWING STUDIO
DRIVEWAY

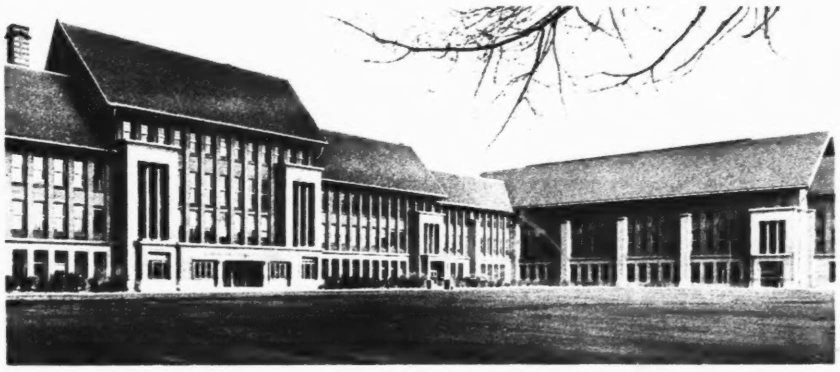
Frank Lloyd Wright's Hillside Home School, Spring Green, Wisconsin—a schoolhouse half a century ahead of its time—1902.

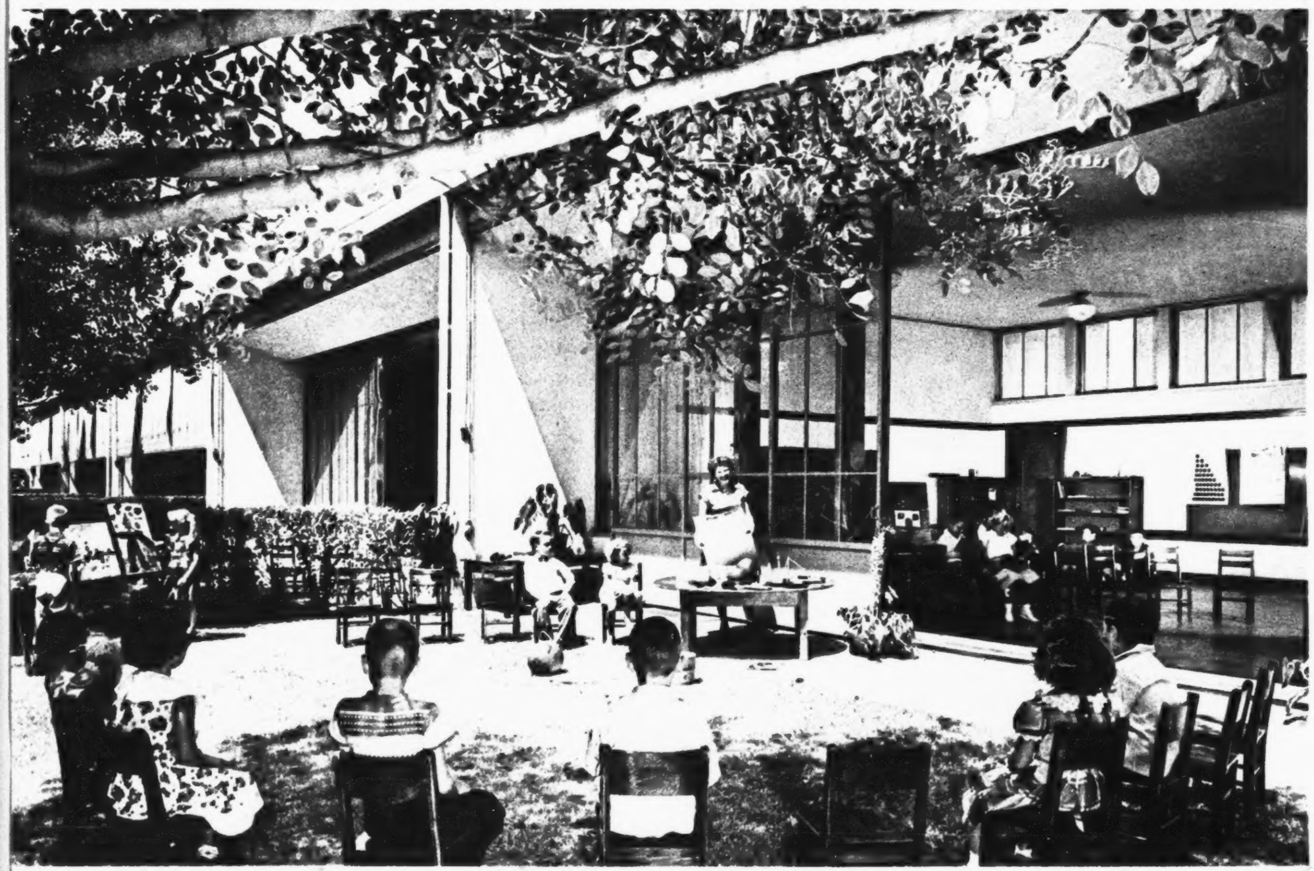
There were notable exceptions to these monumental buildings with their impressive entries and halls and their depressing rooms. Frank Lloyd Wright's Hillsdale Home School in Spring Green, Wisconsin, done at the turn of the century, and Dwight Perkins' Carl Schurz High School in Chicago in 1910 were two that pointed the way toward open planning, a scale more appropriate to the younger generation, and a freedom from the dictates of historical eclecticism. But exceptions were rare until just before the Second World War when an explosion of architectural creativity hit the schoolhouse.

Heralding the explosion was Neutra's work in California in the 1930's. 1940 saw the construction of the Crow Island School in Winnetka, Illinois—a schoolhouse that called considerable attention to its new forms and ideas. Saarinen and Swanson, Perkins and Will, were associated architects. Their building influenced not only school architecture as architecture, but also the relation of plant to program. It was the result, as Lawrence B. Perkins has written, "of months of study on the part of teachers, architects and administrators."

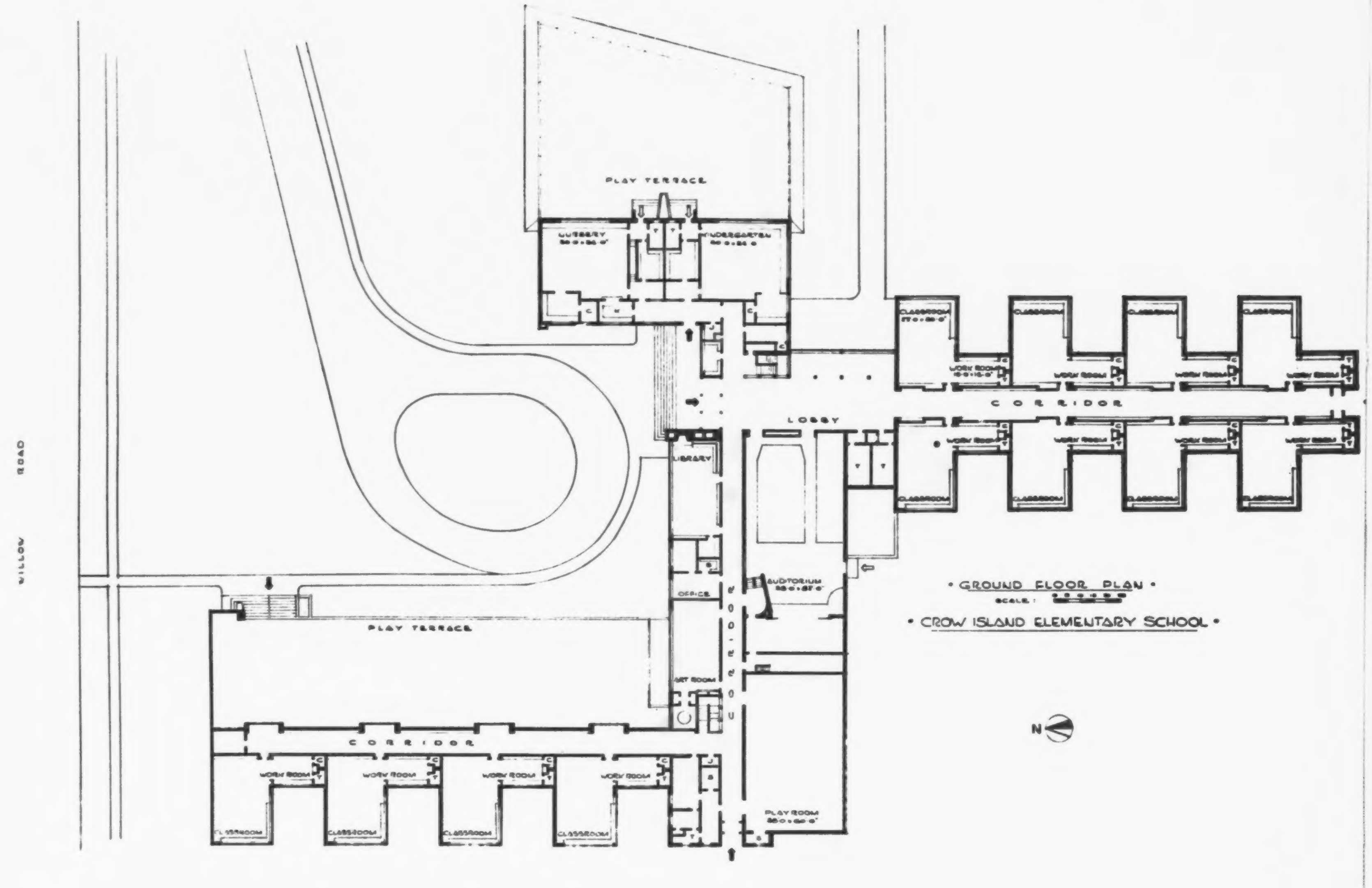


Carl Schurz High School, Chicago, 1910, one of the few schools of the period with architectural originality rather than historical decoration. It's still in use. Dwight Perkins, architect.





Another pioneer of modern school design was Richard J. Neutra who designed the Corona Avenue School, Bell, California, in 1935. It was the first application in the United States of a sliding glass door, combining indoor and outdoor classroom space, and the first school in which classroom corridors were eliminated.


PLAY TERRACE
NURSERY
KINDERGARTEN
CLASSROOM
WORK ROOM
CORRIDOR
LOBBY
LIBRARY
AUDITORIUM
OFFICE
ART ROOM
PLAY TERRACE
CORRIDOR
WORK ROOM
CLASSROOM
PLAY ROOM
WILLOW ROAD
• GROUND FLOOR PLAN •
SCALE :
• CROW ISLAND ELEMENTARY SCHOOL •
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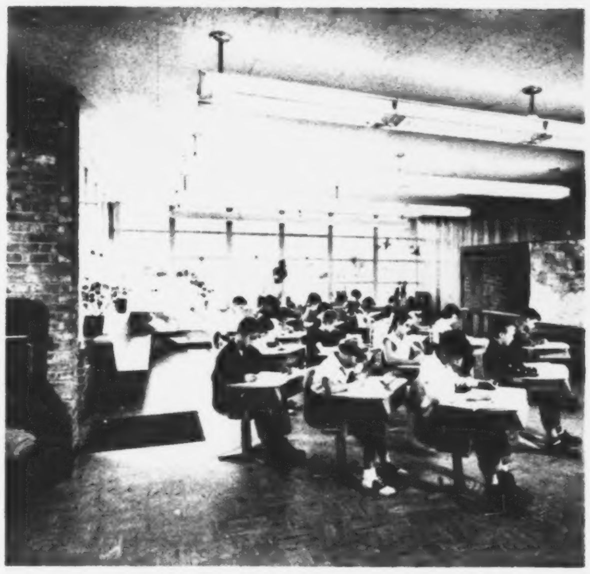
Crow Island Elementary School. "Each room was to be a colorful, flexible, child-scaled work space." The architecture flowed from the idea of the self-contained classroom. Saarinen and Swanson, Perkins and Will, associated architects.

No architectural historian could overlook today's schoolhouse in America or abroad. Experimentation in forms and materials and an increasing realization of the importance of education all over the world combined to set this explosion off. Giedeon, who turned his back on the schoolhouse in 1940, devotes a whole section to schools in his *Decade of New Architecture*, published in 1951. He describes schools in the United States, Holland, England, Switzerland, and Puerto Rico. But notable examples could be found in Scandinavia, Japan, Germany, and Latin America. Walter McQuade's *Schoolhouse*, with a gallery of magnificent illustrations of postwar schools in the United States, is high testimony that some of the finest in modern architecture is represented in our new schools.

From the drab three-story school with its asphalt or gravel yard and wire fence, new forms have sprung. One-story schools have fingers of classrooms reaching out for sun and air. Hexagonal, pentagonal, and round clusters of school rooms break up the forbidding massiveness of yesterday's schoolhouse and invite the pupil to enjoy education. Loft plan schools with movable interiors admit our inability to predict the future of education and allow for tomorrow's change. Campus schools with a number of buildings isolating functions within the school are breaking down the big school into units of manageable size so that the identity of the pupil isn't erased in the institution operated, theoretically at least, to develop him as an individual.

Classroom, Crow Island



With this sudden eruption of new forms and with accelerated changes in school program, particularly in secondary education, the typical school board is being asked to make more decisions than ever before. In 1925, the question would be how many classrooms should the school have, and in what classic or Medieval style can we decorate it. Today the same board must examine not only new teaching programs, but also a great variety of architectural solutions involving money, materials, esthetics, and functions. To muddy the waters, inflation has made every new school more expensive than the last.

What were some of the reasons for the changing school? They hailed from several sources. First, there were the aforementioned changes in educational program and philosophy. For example, here are some of the educational requirements called for in the Crow Island School: ". . . the classroom was to be a place for a fully rounded learning and living experience at each age group; that each room was to be a colorful, flexible, child-scaled work space where the learning activity of childhood could be channeled effectively and pleasantly. Fixed seats were ruled out. A room had to be provided where each seat could be placed in any position in relation to the other children, in relation to the teacher, in groups or as individuals, or sometimes even in . . . formal rows . . . Twelve-foot ceilings were barred. Nine feet was accepted as reasonable residence-scale compromise. Light 'from one side only' was removed as a limitation. Two sides were insisted upon. Color, warmth, and a place in which to work and act vigorously—these were keynotes of the earliest program."

These are not qualities people looked for in a school at the turn of the century.

Second, new requirements for functional efficiency, health, and comfort were brought into effect. Lighting standards have changed. Safety and economy brought the school down, often to one story. The three-story buildings of the turn of the century were often severe fire hazards. Fire safety in multiple story buildings is expensive.

In the search for proper ventilation it should be remembered that there is no other work area common in our society in which people are packed so long and so tight as they are in even a good school. No office would consider 30 square feet adequate space for an employee. Short of air conditioning, cross ventilation is the best assurance of first-rate ventilation, particularly in warmer climates.

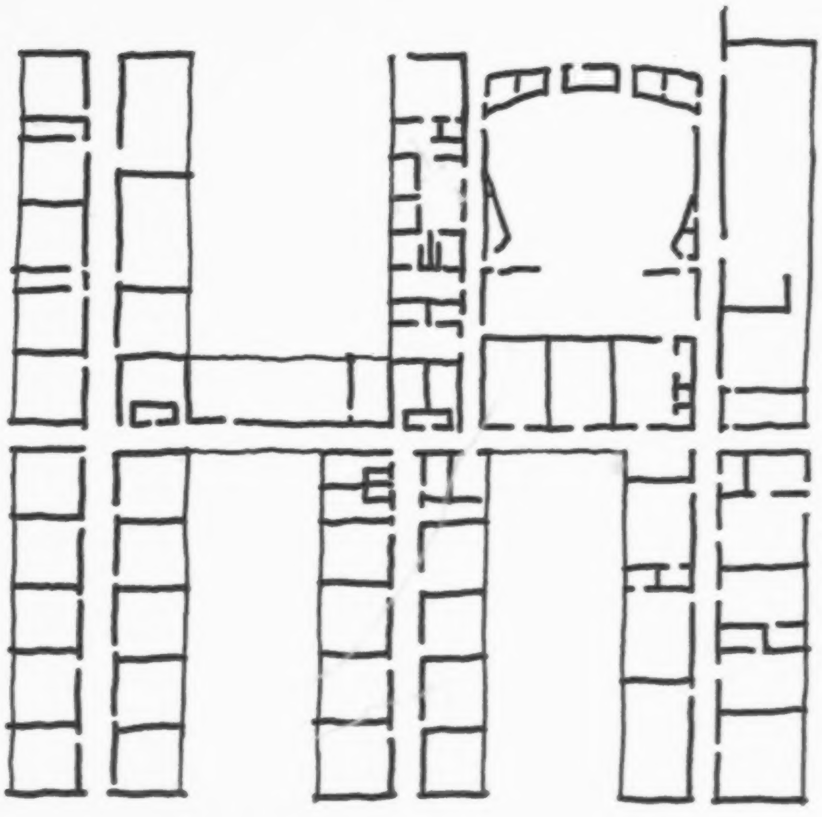
Bilateral lighting, skylights, and clerestory windows are all attempts to equalize the natural lighting on both sides of a school room. Added consciousness of the importance of good lighting for children has spurred architects to open up the school for this reason as well. It was the architects' search for improved ventilation and lighting which contributed to the finger plans and other open plan schools.

American standards of comfort, of ventilation, heating, lighting, plumbing, and furnishing have all changed during the period of more than a century since Barnard described the deplorable conditions of the American schoolhouse in 1848. No one would seriously consider using the public highway as a toilet for the school as was commonly the case in Barnard's day, nor would we return to the 1880 standards of toilets in the basement of a three-story building. Most standards have changed less dramatically than our plumbing standards. But office buildings, hotels and motels, shopping centers, factories, and homes all reflect changes in accepted standards of comfort and architecture. The schoolhouse shares in the standards of the society which produces it.

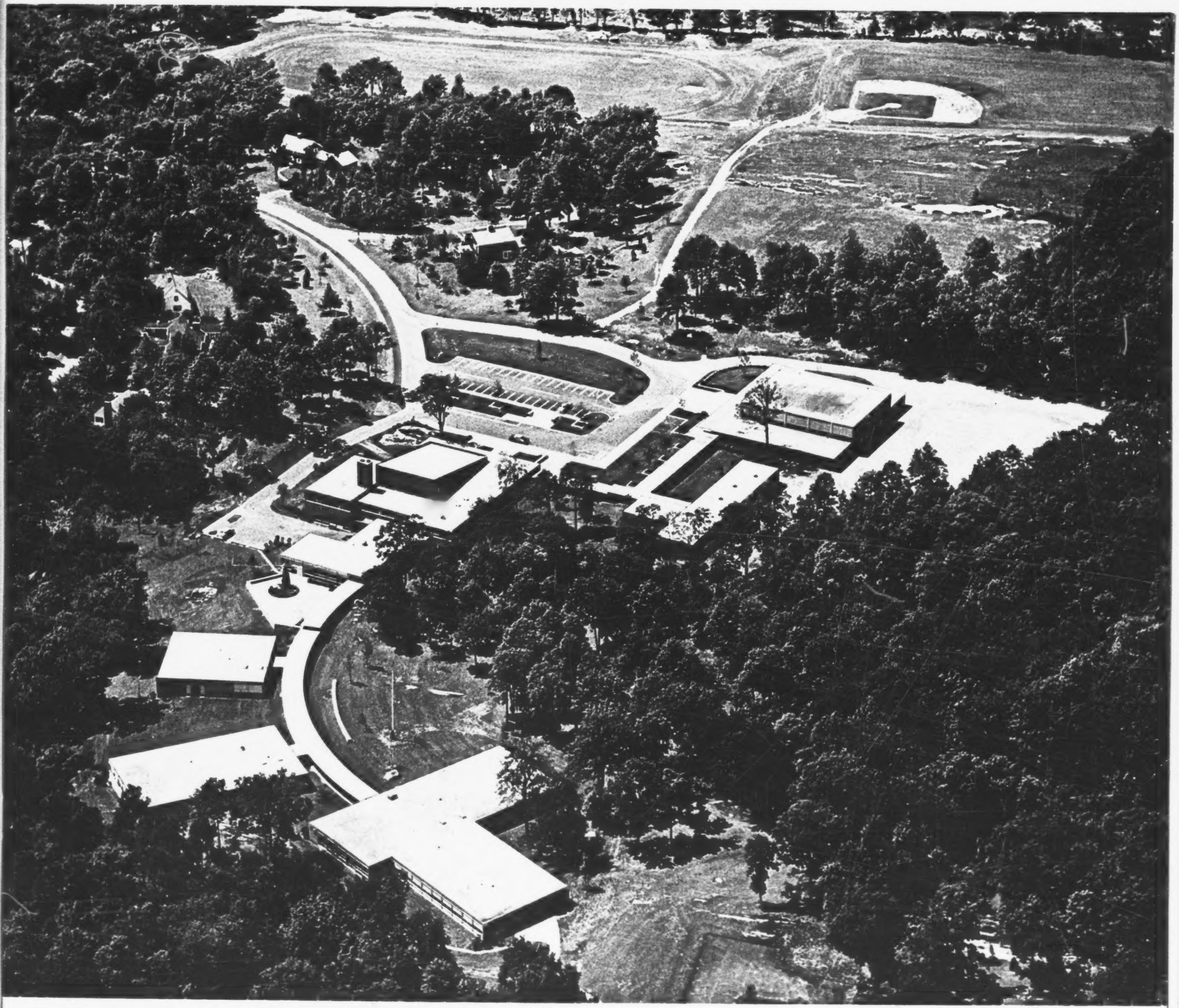
A third important, though less tangible, contribution has been the search for an appropriate scale and aesthetic expression for the school. With the disappearance of classic decoration suggesting classical knowledge and academic Gothic suggesting the medieval university, the archi-

The Heathcote School, Scarsdale, New York, 1953, product of the search for a new scale and form. Perkins and Will, architects.

Finger Plan

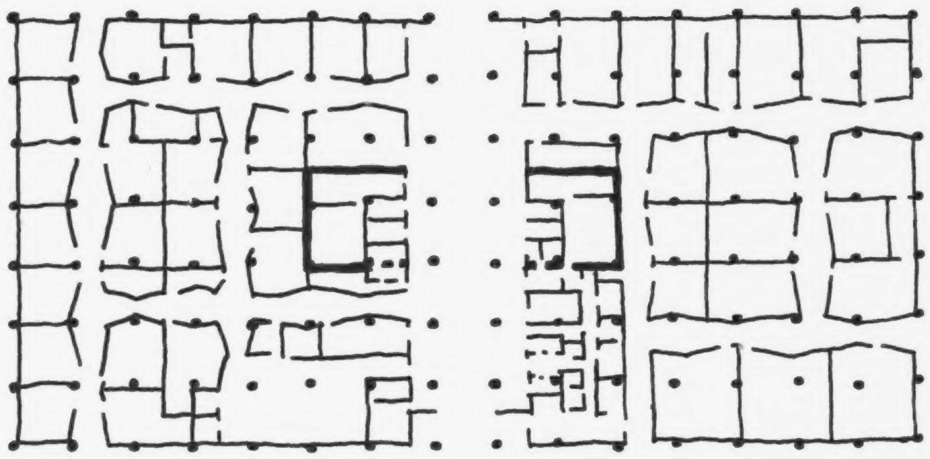


Finger plan proposed for F. Ware Clary Junior High School, Syracuse, New York. Pederson, Hueber and Hares, architects.



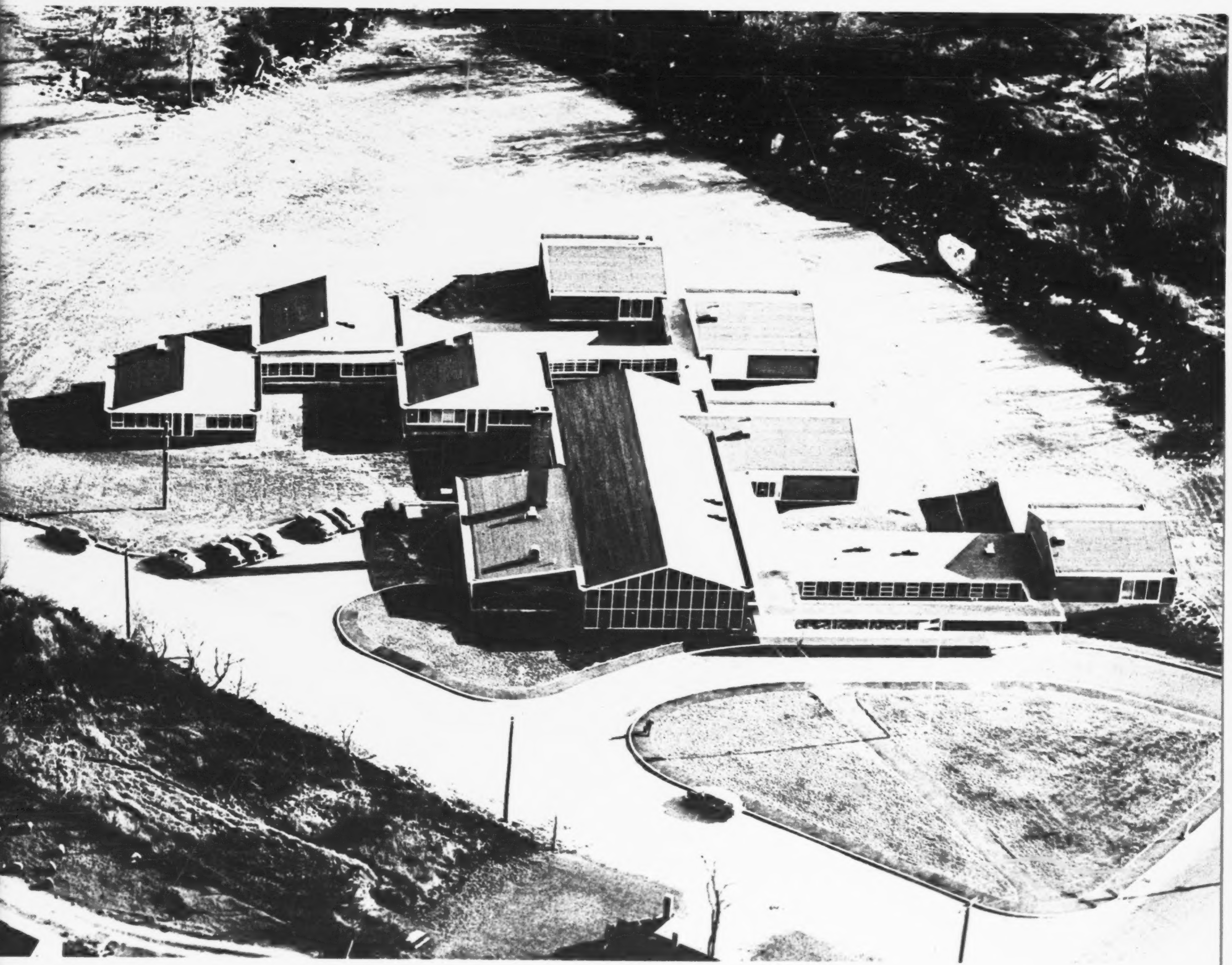
Edgemont Junior-Senior High School,
Greenburgh, New York. Warren H. Ashley, architect.

Campus Plan



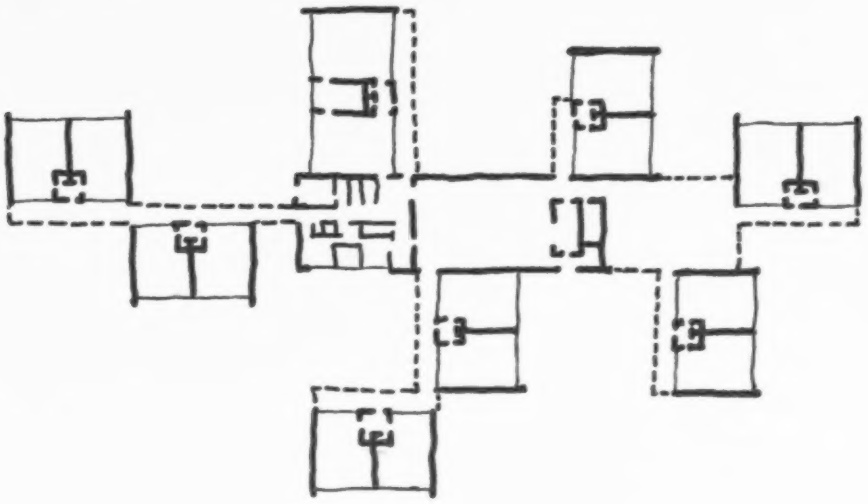
Loft Plan

Hillsdale High School, San Mateo,
California. John Lyon Reid and Partners, architects.

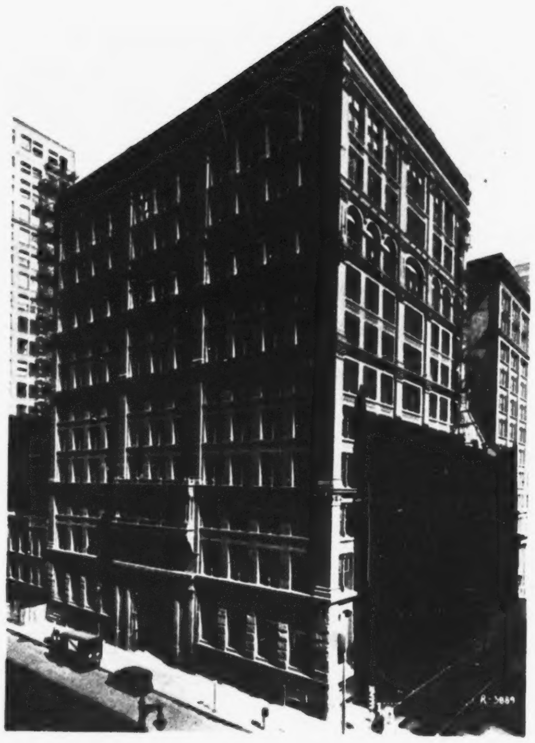


Tower Street School, Westerly,
Rhode Island. Alonzo J. Harriman, architect.

Cluster Plan

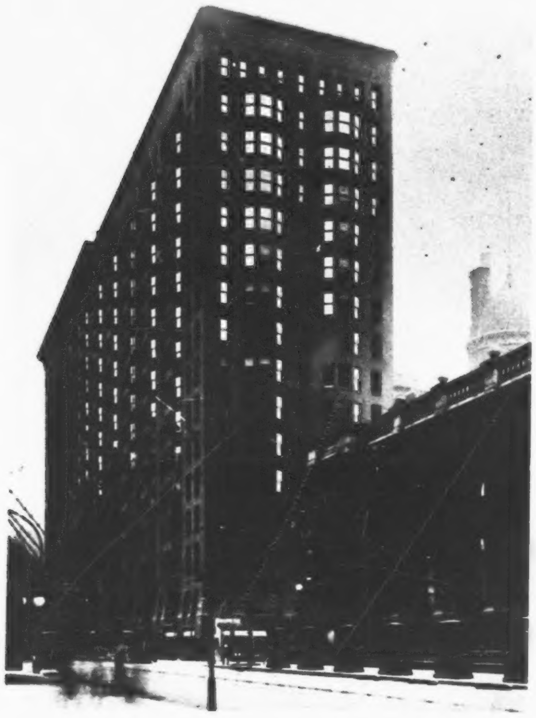


Hollow Tree School, Darien, Connecticut.
Ketchum, Gina and Sharp, architects.



First of the skeletal skyscrapers was William LeBaron Jenney's Home Insurance Building, Chicago, 1885. It was supported entirely by its iron frame.

Monadnock Building, Chicago, the last of the great masonry skyscrapers, 1891. Note the thickness of the supporting walls at the ground floor level. Burnham and Root, architects.



tect starts afresh with the question of how a school should look. Generally the trend to humanize the school and to reduce it in scale, particularly the elementary school, has been a continuing objective. Let the school be inviting rather than imposing. To a lesser extent this has been true of the secondary school as well. In an effort to reduce the impersonality of large high schools, the school program and administration have been decentralized. This has been expressed in the decentralization of buildings both to clarify and to contribute to this concept.

A fourth reason for change has been architectural development. The historical styles are gone. New shapes, new forms, a desire to use machine-made and natural materials more frankly and honestly, and the disappearance of applied decoration in favor of integral design characterize the better schools today.

These developments are more apparent if we turn to architecture in general for a moment.

American architecture in the latter half of the nineteenth century was developing in an original and indigenous direction during what Lewis Mumford has called the "Brown Decades." H. H. Richardson was developing new forms. The schism between architecture as art and engineering was bridged. Louis Sullivan and the other members of the Chicago school were acknowledging without apology the machine age, the skyscraper, and the exterior wall no longer designed to hold up a building but hung there to shield it from the elements.

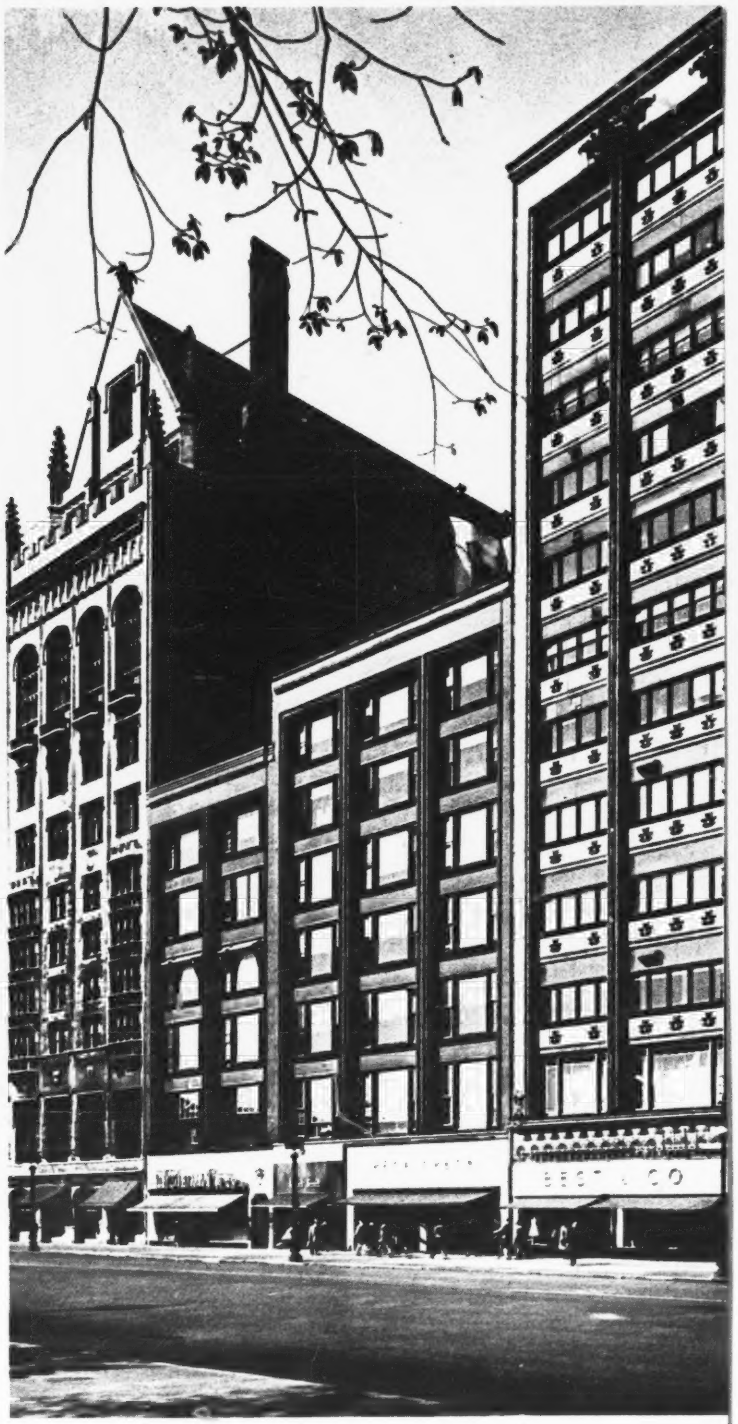
In 1885 the first true skeletal skyscraper was completed in Chicago by William Le Baron Jenney, and the greatest architectural revolution in history was under way. Jenney's Home Insurance Building was supported entirely by its iron interior framing.

Two new materials made this revolution in building possible: the development, in 1855 by Bessemer, of the process by which economical structural steel was made available and the development, by the French engineers Hennebique and Coignet, of reinforced concrete.

These two materials have been vital to the development of contemporary architecture. Structural steel with its strength, ability to span great distances, and its resilience soon replaced cast iron; reinforced concrete with its economy and its flexibility combined some of the more desirable qualities of steel and masonry.

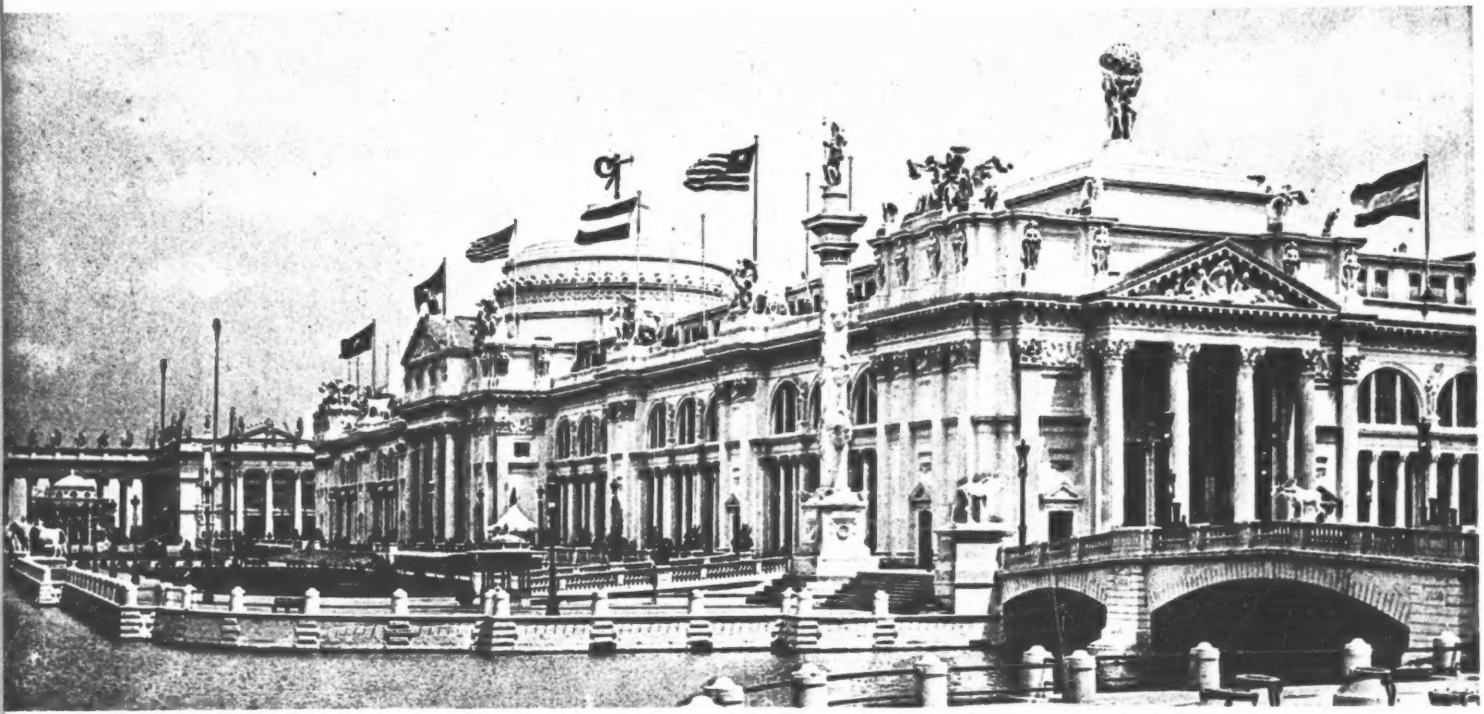
Louis Henri Sullivan became the most articulate spokesman of this changing architecture in America. He wrote in 1896, ". . . form ever follows function and this is the law. Where function does not change form does not change." Why should a bank look like a Greek temple or a high school like a Gothic cathedral? And why should an office building look like a collection of ". . . separate, distinct, and unrelated buildings piled one upon the other until the top of the pile is reached," rather than simply a top and bottom and a series of identical floors between made to "look all alike because they are all alike."

But Americans were not confident of the validity of their own aesthetic developments. The overwhelming success of the neoclassicism of the New York firm of McKim, Mead, and White at the World's Columbian Exposition in Chicago in 1893 set back American architecture a generation. The primacy of historical eclecticism in architecture was reestablished. "It killed Sullivan and it almost killed me," wrote Frank Lloyd Wright.



The Gage group, three late examples of the Chicago style, 1898-9, which still look modern today. Louis Sullivan's building (right) was originally only eight stories, the top four were added in 1902. The two buildings in the center were by Holabird and Roche. To the left is a more contemporary, or at least newer, addition to the Chicago skyline.

The Chicago World's Fair of 1893 turned American architecture back to sterile historical eclecticism. McKim, Mead and White's Agricultural Building at the Fair was typical. "The damage . . . will last for half a century" said Louis Sullivan.



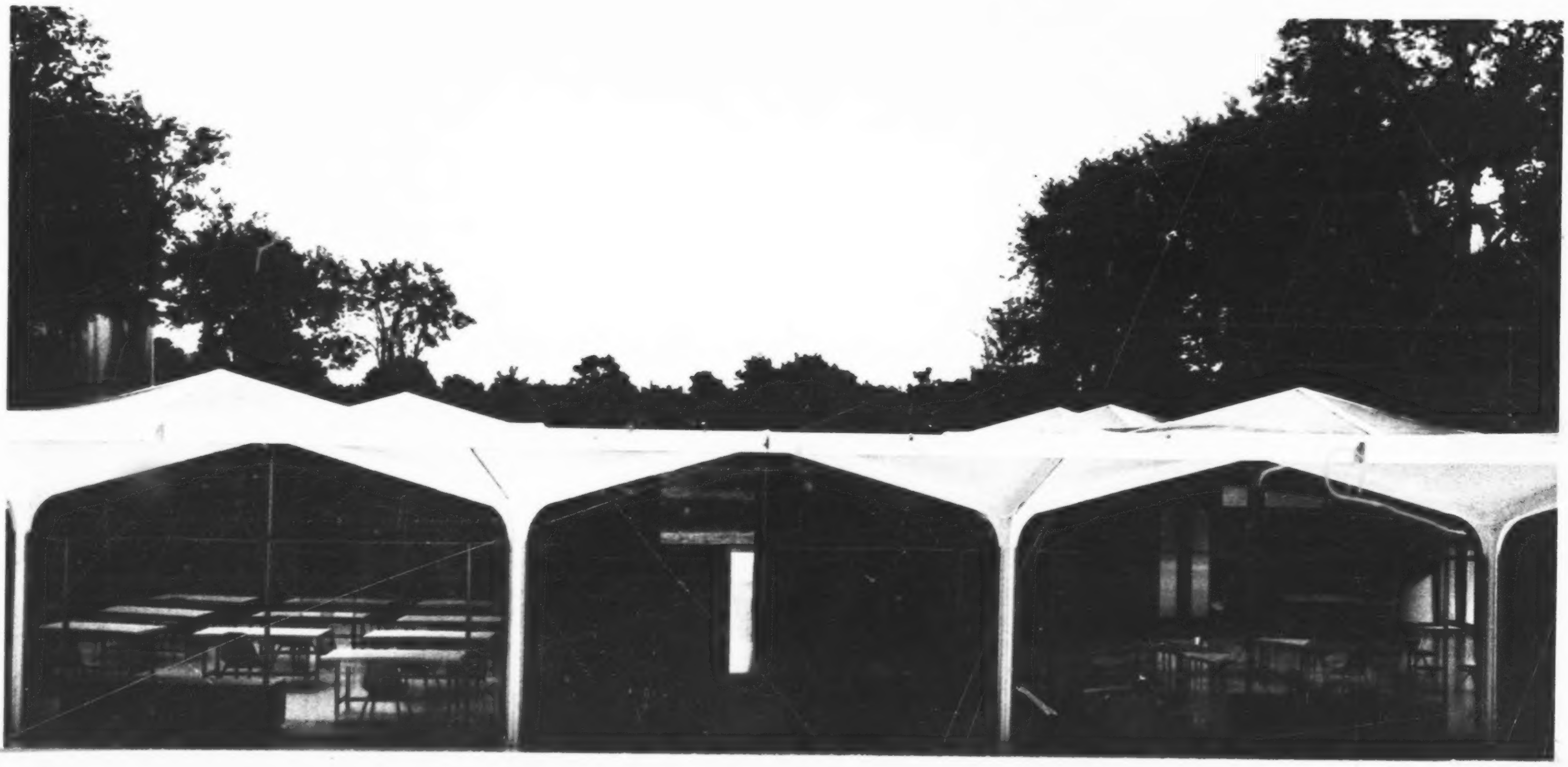
Mr. Wright's near demise seems somewhat exaggerated, to paraphrase Mark Twain, for he survived an additional 66 years, but the general run of architecture in America suffered greatly, and many of the things that Jenney, Root, Sullivan, and Wright were pursuing only came back to America a generation later through the work of European architects such as Gropius, Le Corbusier, Mies Van der Rohe, Dudok, and their colleagues.

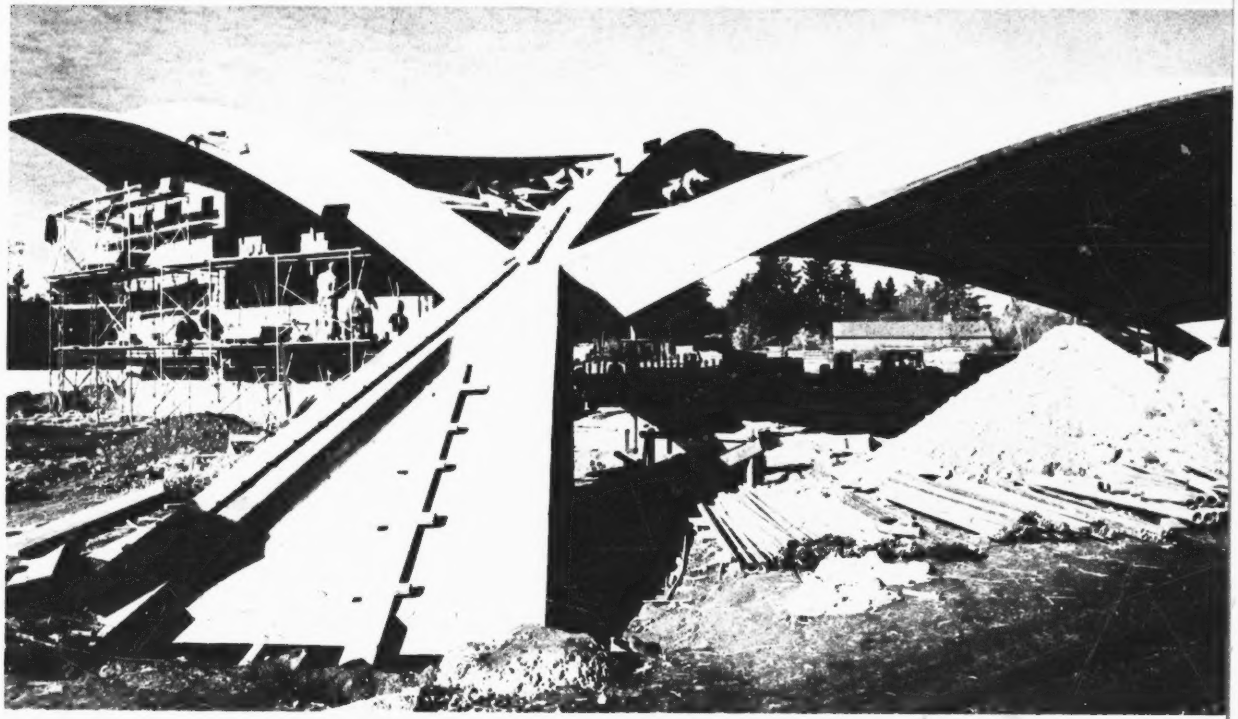
During the depression, architects, among others, had plenty of time for thinking and planning, albeit on an empty stomach. With the end of the depression came war and the necessary curtailment of much building. After the war came the building boom and suddenly ideas sprang from the drawing boards to change the face of America and most of the world. And the end is not in sight. New curvilinear forms in thin shell reinforced concrete, Buckminster Fuller's geodesic dome, new methods of earth moving, plastics for building, laminated wood, and new adhesives may revolutionize building as much as William Le Baron Jenney's Home Insurance Building.

New forms, new materials, and new ideas in school building—

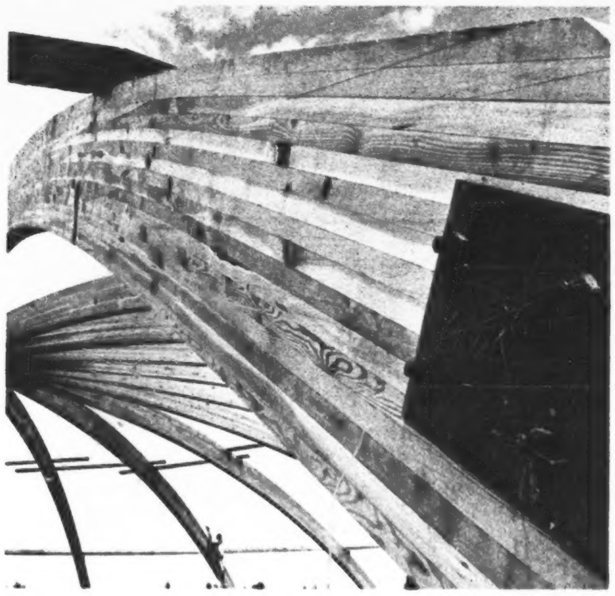
Thin shell concrete makes the dome of Eero Saarinen's auditorium (left) at the Massachusetts Institute of Technology, Cambridge.

M.I.T., with assistance from Educational Facilities Laboratories, Inc., is continuing development of the school below, built of a series of plastic hyperbolic paraboloids, light, strong, and quickly erected.

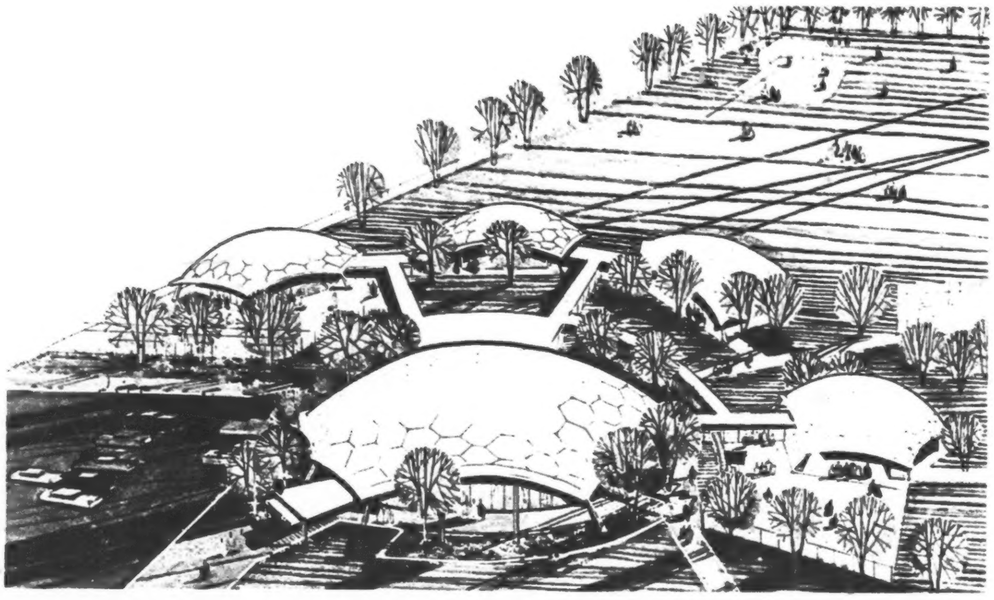




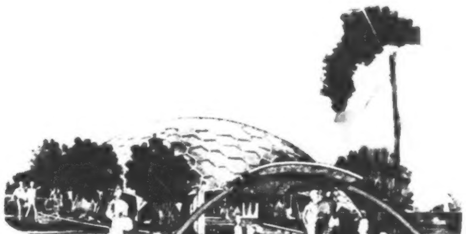
Thin shell concrete is used for the hyperbolic paraboloids of Washington's North Seattle High School. Naramore, Bain, Brady and Johanson, architects.



Laminated wood arches span the auditorium of the Hunt School, Tacoma, Washington. Robert B. Price, architect.



The geodesic dome school built of repetitive mass produced elements, was designed for Kaiser Aluminum Company by Mason, Muntz and Associates, architects.



What have these changes in school building meant in terms of dollars?

Have school costs gone up? The answer is yes. Have they gone up more than other building costs? The answer is no. A U. S. Department of Commerce study, shown in the graph on this page, indicates that educational buildings have, in fact, been holding the line in the inflationary postwar period. While the cost of building schools has gone up, it has not gone up as much as the cost of commercial or other institutional buildings.

As a background for examining school costs, let us look for a moment at what has happened to building costs in relation to other sections of the economy. (See table to the left.)

Obviously building costs have risen more than many other costs—more than the cost of building materials though somewhat less than the cost of labor in the construction industry. Two factors account for this.

One is the increasing *quality* of building today compared to that of 15 or 20 years ago. (There are more amenities in today's building, such as more and better plumbing, better heating systems, air conditioning, and greater electric load capacities. Greater fire safety also costs money but is expected today.)

The other factor is the rather small increase in productivity in the building industry. New building output per contract construction worker was 12.7 per cent higher in 1957 than in 1948, while the average Gross National Product per worker in the economy as a whole rose 22.9 per cent in the same period. (One of the reasons for this may be that buildings, even with prefabricated parts and modular construction, are still to a large extent handcrafted affairs. They are put together bolt by bolt, brick by brick, and there is a limit to the number of bricks one man can and will lay in an hour.) Whether building productivity can be increased at a rate comparable to other fields is open to debate.

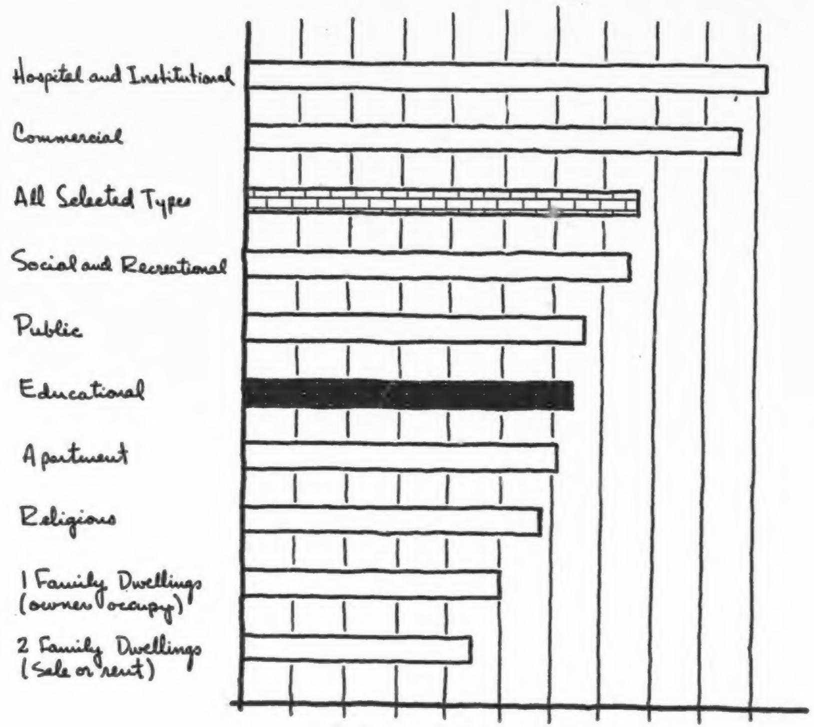
Changes in Selected Cost Indices 1915–1956

	% increase to 1956 from 1915 base year
All items (consumer prices)	255%
Farm products (wholesale)	241% *
Food (consumer prices)	272%
Farm Wage rates	531%
Textile Products (wholesale)	257% *
Apparel (consumer prices)	181%
Metals and metal products	231% *
Average hourly earnings, production workers, all mfg.	888% †
Building materials (all)	468%
Structural steel shapes	396%
Cement	347%
Hourly wages, all building trades	636%
Building cost index (ENR)	515%

* Approximation, not strictly comparable
† Base year, 1914

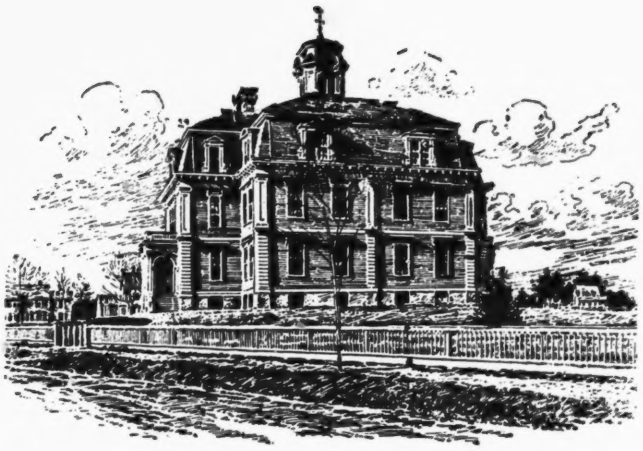
SOURCE: Department of Commerce, Department of Agriculture, Department of Labor Statistics, National Industrial Conference Board

Source: Benjamin D. Kaplan. "Trends in Valuation per Square Foot of Building Floor Area in 37 Eastern States" **Construction Review**, U. S. Department of Commerce, May 1958.



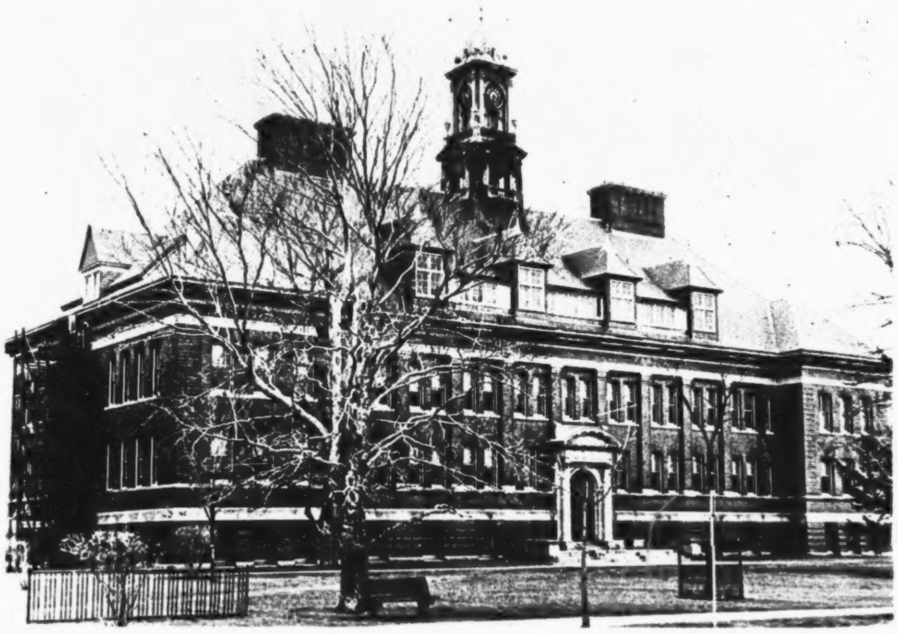
Per Cent Increase in Costs of Building 1949-1956

The Evolution of a Schoolhouse



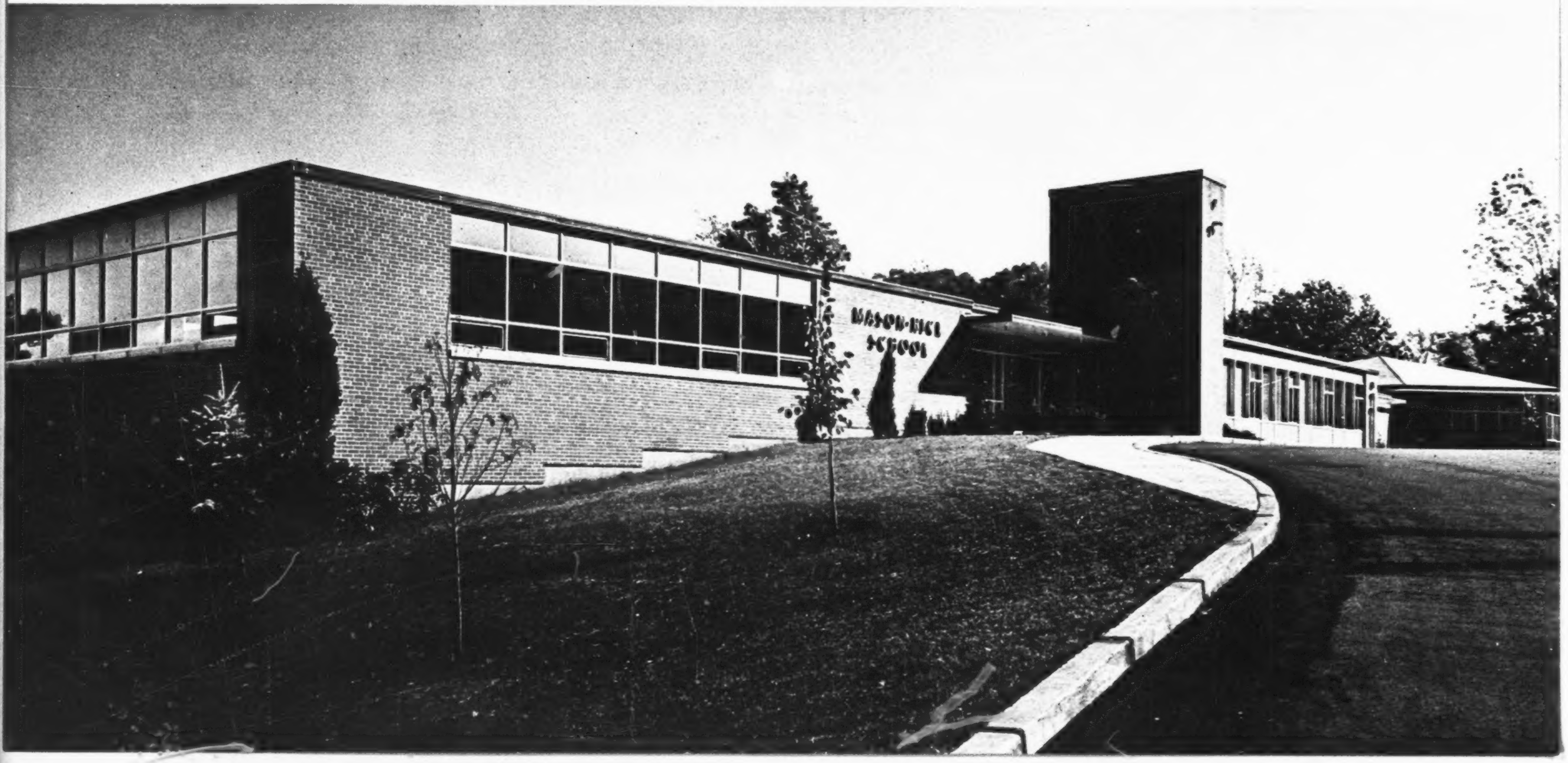
The original Mason School, 1852-1901

Newton, Massachusetts



Second Mason School, 1901-1959

The Mason-Rice School, 1959
Rich and Tucker Associates, architects.



PLANNING

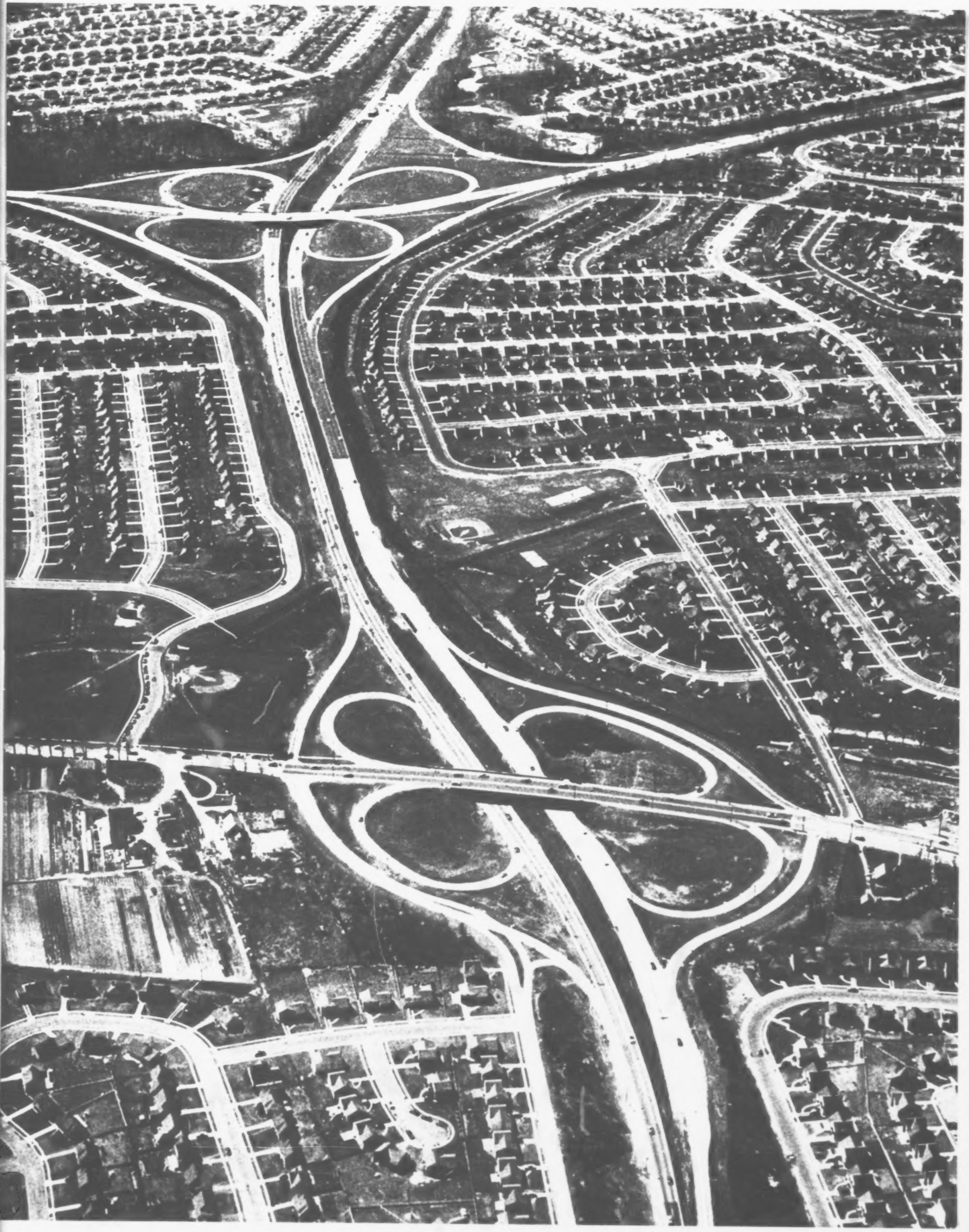
"In every affair consider what precedes and what follows, and then undertake it."

EPICTETUS

The right schools, in the right places, at the right times . . . these are the aim of system-wide planning. Often benefits beyond even these accrue. In San Mateo, California, early site acquisition saved the cost of a high school. Conversely, another California community may lose $1 million on transportation costs alone, due to *lack* of system-wide planning.

Keeping ahead of continuing crisis begins with thinking about the total constellation of all the school buildings in the community and not just about individual schools one at a time. It requires the periodic assessment of existing facilities and the relation of current need to future need.

- Are the present schools adequate?
- Are they well located?
- Is there a projected schedule for the replacement or rehabilitation of schools as they become antiquated?
- Is there (and will there continue to be) a proper balance of space between elementary, junior high, and senior high schools so that all levels can be kept reasonably full from decade to decade?
- What changes are taking place in the community?
- If population is increasing, what is the nature of the growth? If it is decreasing, what is the nature of the shrinkage?
- Will there be other schools—private or church-related—which will duplicate the public facilities?
- Is the school system large enough to run good schools economically, or should it plan for consolidation?



Site of the Hillsdale School, San Mateo, California, just five years ago and the site as it looks today.

Economy is an important aim and benefit of system-wide planning. While discussions of school economy usually are focused on a single building, system-wide planning may offer greater possibilities for real economies than any other part of the school planning and building process. For example, take San Mateo, a bursting California community. This case study deals with just one phase of their system-wide approach—the acquisition of building sites. It shows how the ultimate economy of a school building program may be determined long before the architect sets pencil to paper. By early acquisition of sites money was saved—$3.5 million to pay for the cost of an entire high school.

San Mateo lies 15 miles south of San Francisco, an offspring of the exploding metropolis. Following World War II, it began to experience a tremendous population growth. While in the 30 years between 1920 and 1950 its population grew from 6,000 to 42,000, in the decade that followed the figures spurted dizzily upward, more than tripling to a current population of 133,000. Enormous new residential areas, industries, shopping centers, highway expansion, and commercial and recreational establishments have all contributed to this spectacular growth.

Early in the 1950's, faced with the necessity of some type of long-range planning, the Board of Education called in professional consultants from Stanford University and initiated a continuing system-wide study. Their approach was twofold: (1) to predict future school population, and (2) to spot the location of future building sites. By analyzing existing facilities and their capacities and making an accurate estimate of future needs (see enrollment graph), the study attempted to arrive at the number and type of additional school buildings that would be needed.

The study's forecast of the future high school population showed that their 3,000 pupils (in 1950) would almost triple in number by 1962. These estimates, plus a combination of sharply rising land values and imminent land saturation, moved the community, therefore, to acquire five sites from three to ten years in advance of actual need.

The difference between the value of the land at the time of purchase and at the time of actual or estimated construction is at present computed to be on the order of $3 million. (See Table I.)

High School Enrollment

San Mateo, California

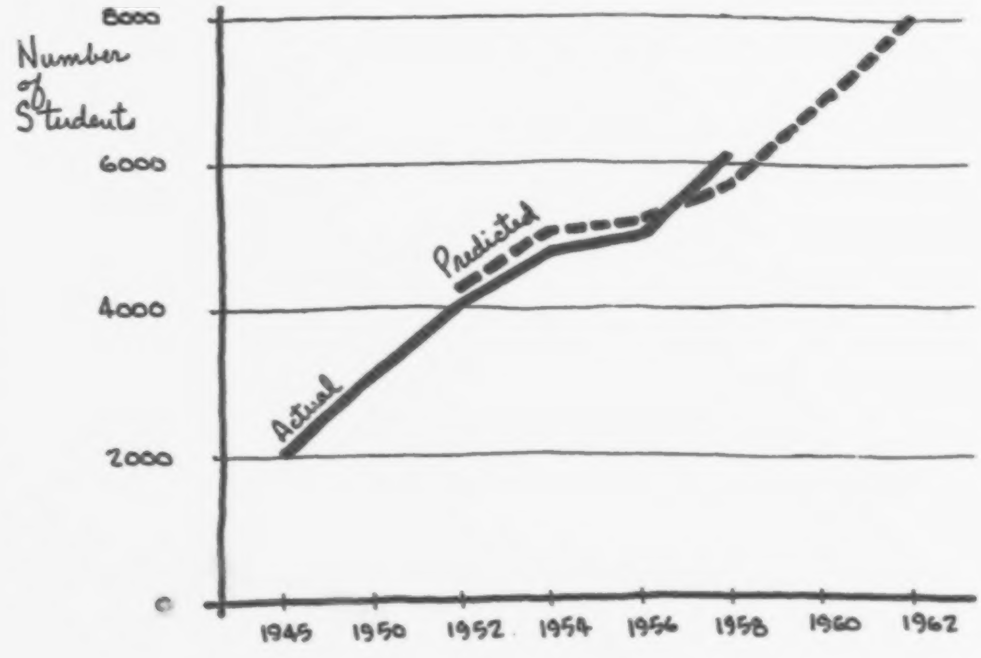


TABLE I

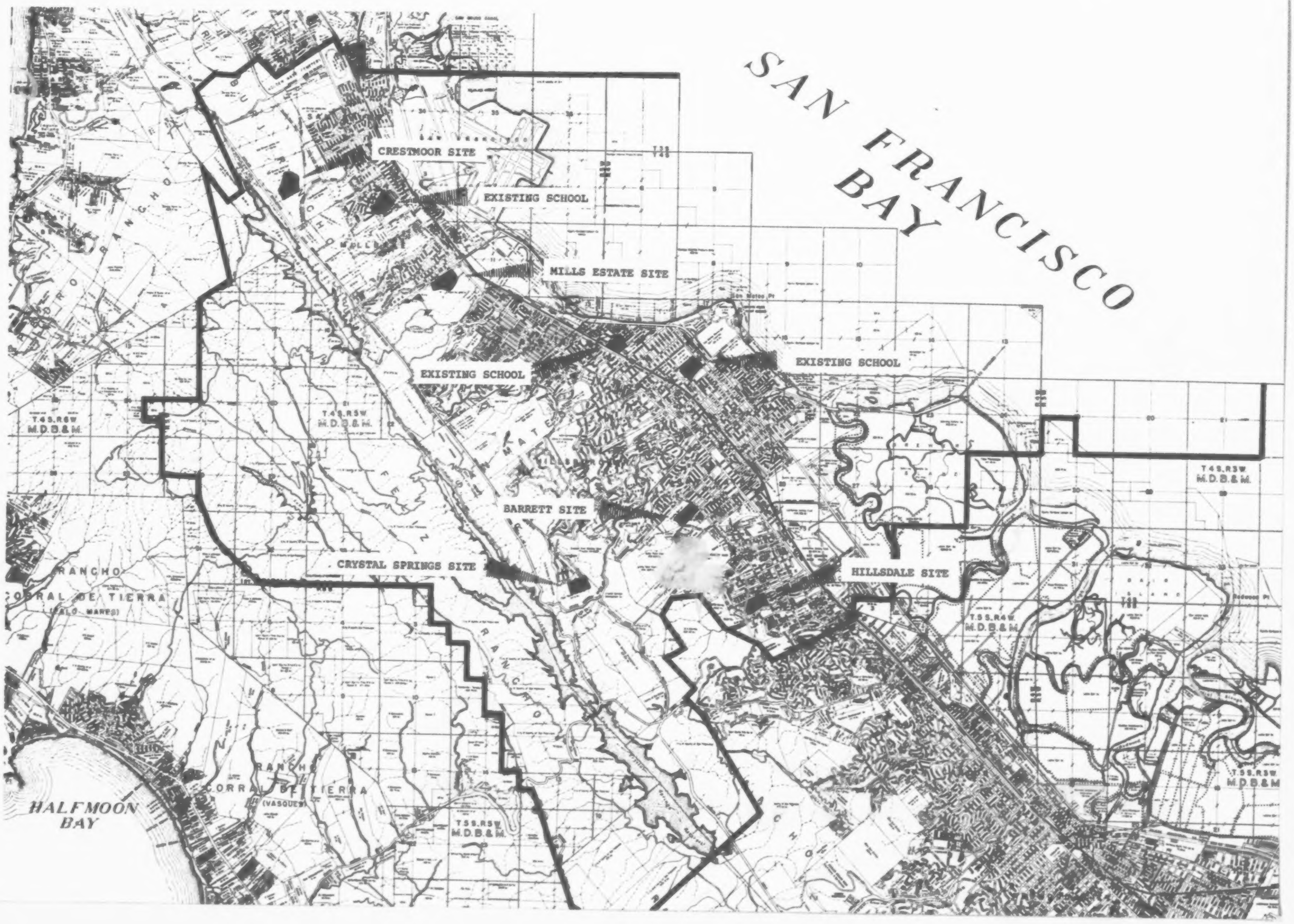
Site	Acres	Pur-chased	Per Acre Cost	Construc-tion Date	Estimated per Acre Value at Construction[a]	Increase per Acre	Valuation Differential between early Acquisition & Construction
Hillsdale	35	1949	$6,750	1954	$20,000	$13,250	$ 463,750
Mills Estate	39	1953	6,600	1957	35,000	28,400	1,107,600
Crystal Springs	40	1954	3,100	1964	25,000	21,900	876,000
Barrett	30	1957	9,000	1960	18,000	9,000	270,000
Crestmoor	40	1957	8,000	1962	24,000	16,000	640,000
							$3,357,350
						PLUS INCOME	400,000[b]
							$3,757,350
						LESS EARNING POWER	225,812[c]
						NET DIFFERENTIAL	$3,531,538[d]

[a] The estimated values were determined by a consensus of three qualified real estate appraisers who have long experience in the community and were involved in some phase of the acquisition of one or more of the above sites.

[b] The district has to date realized some $400,000 in income from the sale of soil taken from the Barrett and Crestmoor sites for fill. The soil was removed in the course of earth moving operations in accordance with district specifications designed to prepare the sites for school building construction.

[c] This figure represents the amount of money which was lost to the school district by taking the above properties off the tax rolls, plus the amount of earnings which the purchase price of the properties would have yielded (at 3½%) during the period the property was not being used.

[d] The total savings which will accrue to the school district from the early acquisition of these sites is equivalent approximately to the construction cost of one large high school.


SAN FRANCISCO BAY
CRESTMOOR SITE
EXISTING SCHOOL
MILLS ESTATE SITE
EXISTING SCHOOL
EXISTING SCHOOL
BARRETT SITE
CRYSTAL SPRINGS SITE
HILLSDALE SITE
RANCHO CORRAL DE TIERRA
HALFMOON BAY
T4S R5W M.D.B.&M.
T5S R5W M.D.B.&M.

The true savings in a situation such as this can never be determined with scientific precision. Nor can there be a precise financial and educational accounting of the losses due to lack of planning. How do you begin to compute the cost of misplaced buildings with their excessive pupil transportation charges? Or inferior sites which dictate higher construction costs? Or overcrowded classrooms? Or double sessions? One of these or all of them can be the result of lack of planning. The last item alone, double sessions, can by itself mean a substantial waste of money, since instructional costs represent more than 65 per cent of the education dollar. Under a double session schedule a building must be operated in shifts, which means that the time of daily instruction must be reduced from six or seven hours to five. The teaching staff, however, must still be paid for full-time work. Factors such as this, though hidden, are real and are ominous.

Community-wide participation is a benefit of system-wide planning that may operate in so subtle a manner that it sometimes goes unrecognized and cannot be counted in dollars and cents. The system-wide planning process provides an opportunity for the participation of large and diverse groups of people. Sometimes largeness and diversity make for slow and cumbersome movement. But communities must cope with groups who have different points of view, who are motivated by special interests, and who often do not understand or agree on ultimate goals.

While the school board will always carry major responsibility for initiating and carrying out the educational program of a community, that program will flourish and be most successful where it has the active support and understanding of the whole community.

Broad participation makes the knowledge and skills of a variety of people available to the school board. It provides a common ground for communication and understanding among the participants. The very involvement of a broad base of individuals, groups, and agencies all concerned with the pursuit of a common goal—the attainment of a good educational program for their community—is itself a long step toward success.

Such factors as land use policy, the service of utilities that could affect the choice of sites, a commercial development that could cause a shift in population and disrupt attendance boundary lines, and the influx of new industry which would cause a major in-migration of families can upset the best laid plans. State education agencies, university personnel, professional consultants, and the school staff can contribute to the planning process; but the special knowledge of the local planning commission, the Chamber of Commerce, the state department of highways, the local utility company, the superintendent of parks, residential developers, service clubs, bankers, and lawyers is a service that should be tapped. In addition, groups such as parents and citizens committees are in a position to help by supplying pertinent information and by contributing their services for a pre-school census or house count.

POPULATION PREDICTION FACTORS

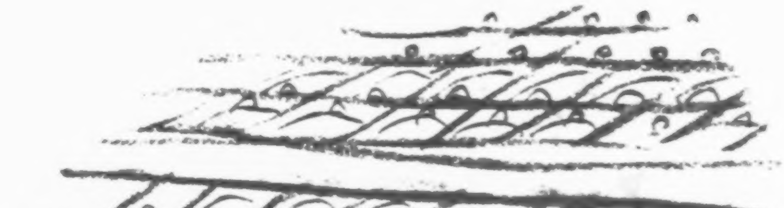
System-wide planning, then, is the first key to economy. The first step is to look into the future and make estimates about it. The estimates should be the result of exhaustive studies of all the factors which can be expected to influence the size and direction of the school district's population growth or shrinkage. How good these estimates are will determine how efficiently the system-wide plan works.

Sometimes, unfortunately, estimates are based on no more than guesses, as in the case of the school board which relied on the town octogenarian's knowledge of "who owned what and who would sell," a sort of intellectual divining rod for determining possible locations of future schools.

One of the factors which complicates enrollment estimating is just a small by-product of that huge phenomenon taking place throughout the world that has come to be called the "population explosion." In America alone, in the 12 postwar years between 1946 and 1958, the population has increased by 33 million people. If the present birth rate continues, by 1980 there will be approximately 260 million Americans. (In about one generation we will have added to our country some 110 million, the population of the United States in 1922.)

In every community throughout the land the basic questions which confront school planners are these:

- How many school age children are there now? What are their ages? Where in the school district are they living?
- How many children will there be five or even ten years from now? How old will they be? Where will they then be living?
- How many of these children, by age and place of residence, must be provided for in the *public schools?*



"When will it ever end, Miss Hartley?
When will it ever end?"

Drawing by Peter Arno © 1936 The New Yorker Magazine, Inc.

The questions are simple enough, but the answers are not. They are compounded by another phenomenon, which is that people are moving around the country at a rate and in numbers unprecedented in our history.

Americans are on the move. The average American family now moves once every 5 years. Just before World War II it was estimated to be every 7 years. Younger families these days move on an average of every 2½ years. And even this rate of mobility is exceeded by families who live in trailers and move once in every 20 months. (The proportion of the nation's annual private housing output represented by mobile homes had reached 14 per cent by 1958.)

This problem of shifting masses of people—where they are moving from, where they are moving to, and in what numbers—becomes another key question for school planners. Given these conditions of population movement and change they must look into land use, home building development, and housing occupancy in their districts. To predict future school needs, it is necessary to know:

- The composition of households living in single, two-family, and multiple-dwelling units.
- The number and type of houses constructed in previous years in various sections of the community.
- The types of families moving into new or converted housing and the number of elementary and high school children per family.
- The trend as to vacancies, demolitions, or shifts from residential to commercial uses.
- The amount of vacant land available for residential construction.
- The type of construction likely to be undertaken on this land and the rate of land utilization for residential construction.

Such housing data are still but part of the information needed. Where new local roads are to be located, which are to be built first, when and where water and sewer lines are to be extended, what commercial and industrial developments are occurring—all these are among the factors that affect the rate of community growth.

If long-, rather than intermediate, range projections are to be made, births must be estimated for a period of at least five years—and this is complicated.

There are no easy formulas which fit all these variables and provide answers to all the questions. Which of the many factors are most important? What data are available and accurate? What additional information can be secured? Local population and school enrollment forecasting demands choice and judgment—choice in the selection of the factors to be studied and judgment of how to fit these pieces of information together.

One thing can be said for certain: an annual pre-school census is the minimum prerequisite to forecasting and system-wide planning. Sometimes the registration of pre-school children can be done by the police or other officers when the house to house registration of voters is taken. Some communities have used high school seniors to take the pre-school census. But the fact remains that failure to take inventory can mean unexpected pressures and strains, with the result that it is often necessary to meet each crisis with hasty and expensive action.

THE END OF A SCHOOLHOUSE

Why is a school discarded as no longer useful? According to the forthcoming report, Economic Planning for Better Schools, *by Professor A. Benjamin Handler of the University of Michigan, which classifies the reasons for abandonment of 54 Michigan schools between 1946 and 1952, the most common were:*

educational obsolescence, 38 cases
poorly located, 29 cases
no interior plumbing, 28 cases
no central heat, 28 cases
no handwashing facilities, 25 cases.

In most situations the discarded schools suffered from more than one defect.

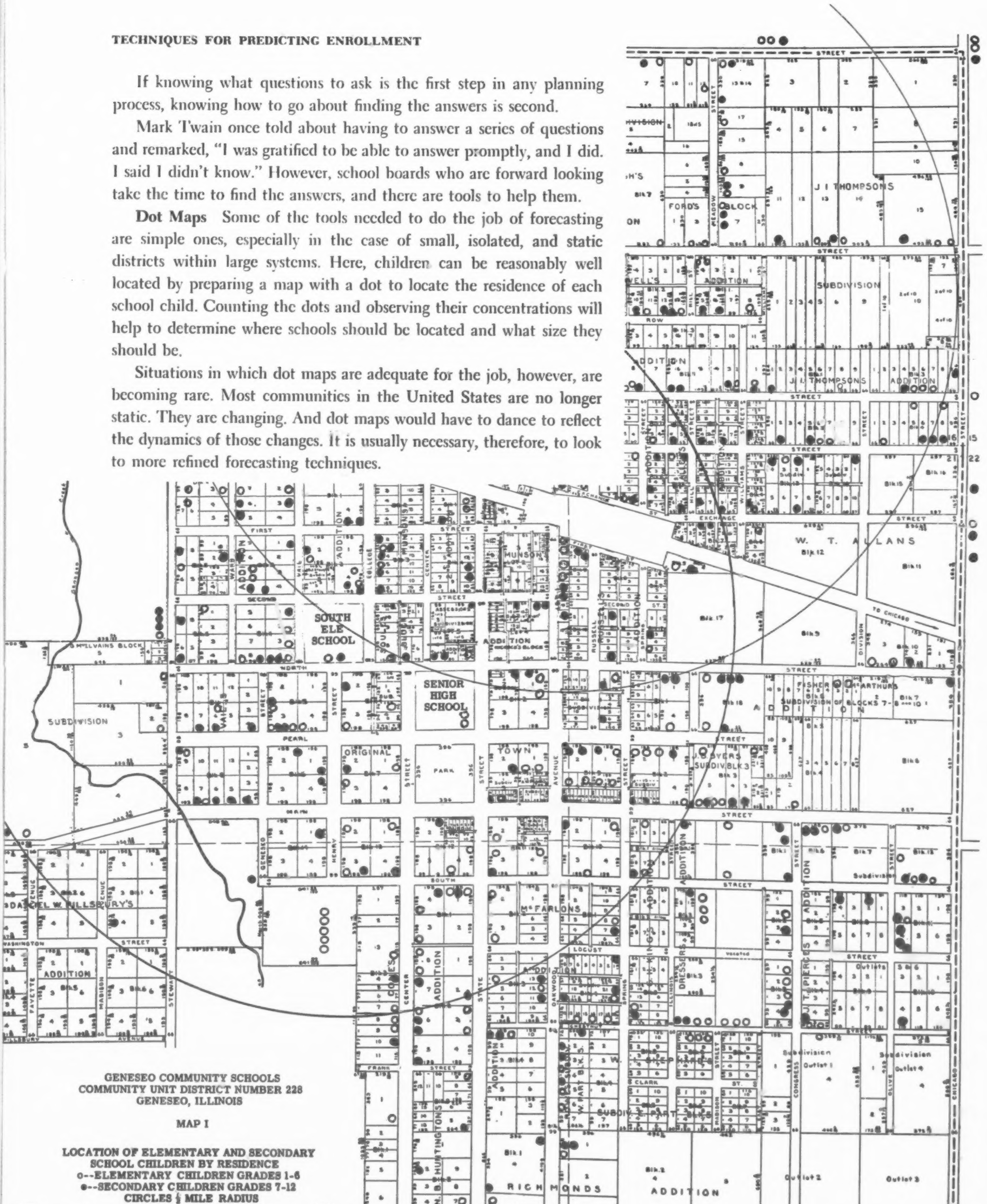
As Professor Handler points out, educational obsolescence is "undoubtedly even more important than indicated. For if legal grounds must be established for abandonment, the justification is made in reference to safety and health." Many of the defects in plumbing, heating, and safety could be corrected if the building were usable. Educational obsolescence and poor location consequently assumed even larger roles as reasons for abandonment than is immediately evident.

If knowing what questions to ask is the first step in any planning process, knowing how to go about finding the answers is second.

Mark Twain once told about having to answer a series of questions and remarked, "I was gratified to be able to answer promptly, and I did. I said I didn't know." However, school boards who are forward looking take the time to find the answers, and there are tools to help them.

Dot Maps Some of the tools needed to do the job of forecasting are simple ones, especially in the case of small, isolated, and static districts within large systems. Here, children can be reasonably well located by preparing a map with a dot to locate the residence of each school child. Counting the dots and observing their concentrations will help to determine where schools should be located and what size they should be.

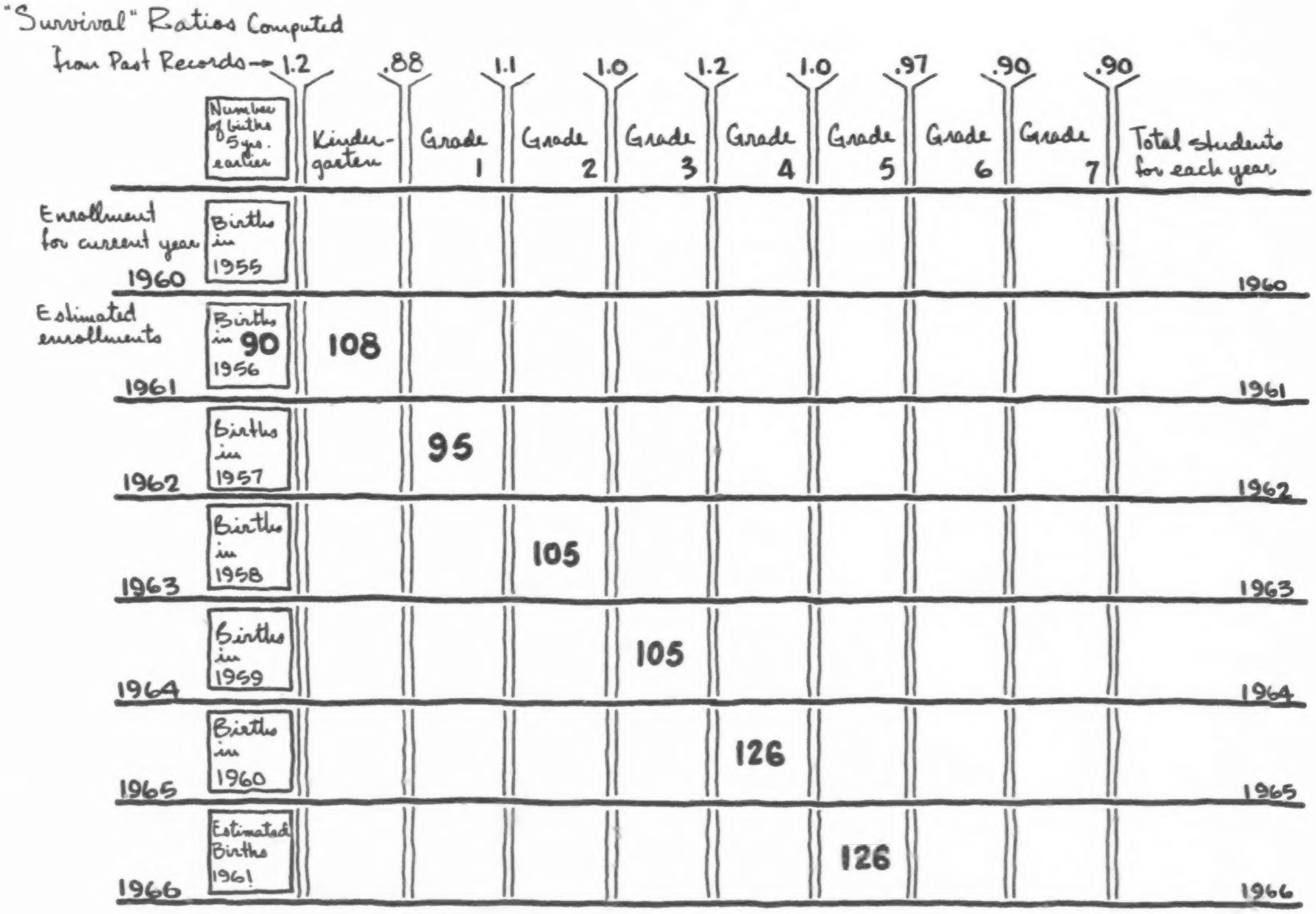
Situations in which dot maps are adequate for the job, however, are becoming rare. Most communities in the United States are no longer static. They are changing. And dot maps would have to dance to reflect the dynamics of those changes. It is usually necessary, therefore, to look to more refined forecasting techniques.



GENESEO COMMUNITY SCHOOLS
COMMUNITY UNIT DISTRICT NUMBER 228
GENESEO, ILLINOIS

MAP I

LOCATION OF ELEMENTARY AND SECONDARY SCHOOL CHILDREN BY RESIDENCE
○--ELEMENTARY CHILDREN GRADES 1-6
●--SECONDARY CHILDREN GRADES 7-12
CIRCLES ½ MILE RADIUS



"Survival" Ratios Computed from Past Records → 1.2 .88 1.1 1.0 1.2 1.0 .97 .90 .90

	Number of births 5 yrs. earlier	Kindergarten	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Total students for each year
Enrollment for current year 1960	Births in 1955									1960
Estimated enrollments 1961	Births in 1956 90	108								1961
1962	Births in 1957		95							1962
1963	Births in 1958			105						1963
1964	Births in 1959				105					1964
1965	Births in 1960					126				1965
1966	Estimated Births 1961						126			1966

An example of a single class is used in this "Percentage of Survival" chart to show how class size can be estimated from year to year for a 6 year period.

Percentage of Survival Technique Among these more refined forecasting methods, the simplest and perhaps the most widely used has been the "percentage of survival technique."

The first step in this procedure is to estimate future enrollments by computing the estimated size of each grade for the next immediate year from the size of the present year's next lower grade. Of the children in any grade, a certain percentage "survive" to enter the next higher grade the following year. This percentage may be more or less than 100 per cent, depending primarily on population changes but also somewhat on the promotion policy of the school system. In a similar fashion, some percentage of this new grade group "survives" again in each subsequent year as it advances to the next higher grade.

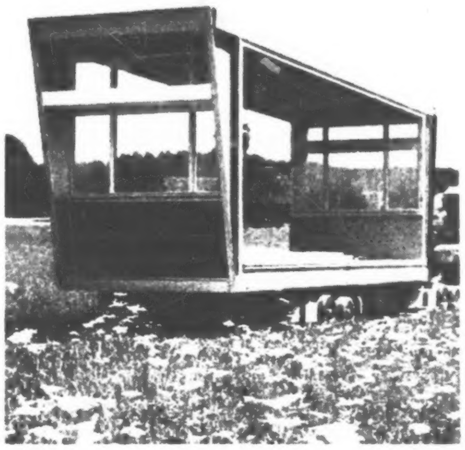
By computing an average of what this percentage of grade to grade survival has been for, say, the past five years, it becomes possible to advance the present total school enrollment year by year, each time dropping the last grade and adding a new first grade group. The size of this new yearly first grade is also estimated by using a "survival" ratio, again based on past experience but this time on the number of births in relation to those entering the first grade. The above graph illustrates this method.

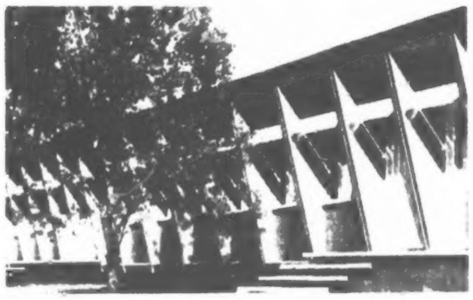
This method of forecasting is neat and orderly. But because of its very neatness, it may not always do the job. It is a technique which should be used carefully and with an awareness of its weakness—a tendency to oversimplify the picture. It takes all of the numerous factors which more or less independently affect school enrollments and welds them into one single factor. It says that "in this community we feel confident that what has been happening in the past is continuing pretty much as it has been," or that "if there are changes they are tending to cancel each other out, leaving the net balance of conditions about the way it was." In view of the quantity and quality of the population movement taking place in America, this is often a dangerous assumption. Some communities have gone wrong in using this technique because of the failure to take into account the sudden in-migration or out-migration from church-related schools.

Long-Term Projections A truly long-range plan for school facilities, district by district, requires the most meticulous study by persons highly sophisticated in demography and city planning. School systems cannot gauge the dynamics of growth in various sections of the city simply by counting noses. The observation of Mr. John Marshall, former Chairman of the Board of Education of New York City, in a letter to the *New York Times*, November 10, 1959, illustrates the difficulty. "The history of the movement of populations in this (New York) city indicates that schools are planned and built at about the peak of child population in the neighborhood. Shortly after the construction of schools the population in most instances begins to decline. This is what happened, for example, at Parkchester. Children grow up and then leave home. When they marry they generally settle in another neighborhood, leaving people beyond the child-bearing age in the old neighborhood."

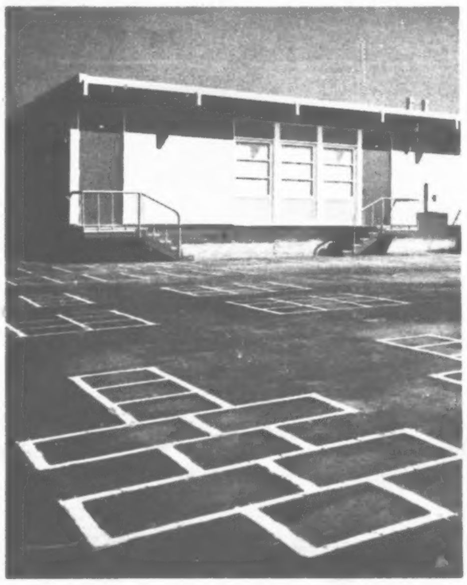
As projections move from 5- to 10- or 15-year periods, the possibility of serious discrepancies between estimates and actual future population change increases. While long-range estimating is necessary because it indicates the *nature* of future growth, it will not determine accurately the need for a given number of classrooms for a given number of pupils. Prudence demands that not more than a 5-year period be considered within the range of reasonably accurate estimation, particularly in rapidly changing communities.

The complexity of projection has caused many a community to resort to transportable schools, to recover quickly from unpredictable changes in enrollment. San Diego, Houston, Baltimore, and Toronto, to name but four school systems, are attempting through mobile school facilities to gain time to plan for permanent facilities by providing temporary facilities.





Both here and abroad there is the need for classrooms which can be quickly assembled, dismantled, and moved on to other places. In Zug, Switzerland, classroom units are transported and set side by side to make a temporary schoolhouse. Fritz Stucky and Rudolf Meuli, architects.
Los Angeles has 3,300 transportable classrooms like the one below.



SYSTEM-WIDE PLANNING AND DISTRICT ORGANIZATION

Overcrowded schools with double sessions are one form of waste, but schools with too few children are another kind. In his recent study of American secondary schools, Dr. James B. Conant singles this out as a subject of special concern: "The enrollment of many American public high schools is too small to allow a diversified curriculum except at exorbitant expense. The prevalence of such high schools—those with graduating classes of less than one hundred students—constitutes one

TABLE II *Total Population and School Age Population (5–19 Years Old): United States, 1850–1980*

	Total population	*School age population (5–19 yrs. old)*
	(in thousands)	
Census enumeration		
1850	23,192	8,662
1900	75,995	24,510
1910	91,972	27,931
1920	105,711	31,470
1930	122,775	36,165
1940	131,669	34,764
1950	150,697	34,936
Estimate		
1957	171,229	44,811
Projections		
1960	180,126	49,782
1970	213,810	62,244
1980	259,981	76,206

SOURCES: 1850: *15th Census of the United States: 1930, Population,* Vol. II, p. 576.
1900–1950: *1950 Census of Population,* Vol. II, Part 1, Tab 1a 39.
1957–1980: U.S. Bureau of the Census, "Illustrative Projections of the Population of the United States, by Age and Sex, 1960 to 1980," *Current Population Reports,* Series P-25, No. 187 (Nov. 10, 1958).

of the serious obstacles to good secondary education throughout most of the United States. . . . such schools are not in a position to provide a satisfactory education for any group of their students. . . . The instructional program is neither sufficiently broad nor sufficiently challenging. . . . Furthermore, such a school uses uneconomically the time and efforts of administrators, teachers, and specialists. . ."

Here again system-wide planning can play a major role. In the course of such planning in many small communities, studies set up to assess the schoolhousing situation point up deficiencies in the existing district organization. These are usually the same—very small enrollments, inadequate educational and auxiliary services, deficient secondary school program, and uneconomic size as an administrative unit. What becomes apparent is that within the existing organizational structure a tax increase may merely replace an old one-room schoolhouse with a new one-room schoolhouse, but it cannot substantially improve the quality of the educational offering. A new school building cannot provide special teachers, for example, to conduct advanced courses in science, mathematics, or foreign languages for the 5 or 6 gifted students out of a graduating class of 30. Nor can a new building with a very small total pupil capacity provide facilities for comprehensive academic and vocational course offerings. The answer is reorganization, pooling the resources of a number of districts into a single consolidated school district. In this way the tax base is broadened, larger pupil capacity is achieved, and the same tax dollar can buy more education. Of course there will continue to be a great number of small schools in areas where population is thin, and steps can and are being made to improve such schools. But where distance between students is not the great problem and small schools persist, consolidation should receive serious consideration.

Consolidation of school districts is not new, but in spite of the overwhelming evidence that larger school systems with wide tax bases result in better and more economical education, we still have some 45,000 school districts in the United States. It has been estimated that 10,000 would be more in line with our needs. In some states the majority of all schools are one-room schoolhouses. (Of a total of 2,847 schools in North Dakota, for example, 2,221 are one-room schools. Nebraska has 3,431 one-room schools out of a total of 4,911.) Many of these are inadequate and outmoded, and such small districts throughout the country would be wise to take heed of Dr. Conant's view, that "citizens who wish to improve public education might well devote their energies to mobilizing opinion in behalf of district organization directed toward the reduction of the number of small high schools."

PLANNING IN METROPOLITAN REGIONS

Most school districts in the United States lie outside the metropolitan areas, but it is *within the metropolitan areas that an ever increasing majority of children will be living.*

In the cities and the suburbs of metropolitan regions system-wide planning is obviously a great deal more complex.

While some aspects of school planning are shared in common by both the city and the suburb, each has its own unique characteristics and problems, and these must be dealt with separately.

Planning in the Cities In the cities of the metropolitan regions, planning will be increasingly bound up with urban renewal. Philadelphia has been a leader in urban renewal programs.

> *Philadelphia has undertaken a vigorous program of urban renewal, a program carried on with the close cooperation of City agencies and the Board of Education. Almost two miles from the heart of its downtown section, there is an area of about 153 acres known as the Southwest Temple Redevelopment Area. In 1948, this area contained some 17,800 people who occupied 5,750 dwelling units. Though it was predominantly residential, a large number of commercial and industrial enterprises were scattered throughout it, and almost every block contained a mixed land-use pattern. (See map of existing land use on page 56.)*
>
> *Like most slums, the area was also characterized by excessive density and excessive coverage of land by buildings in poor repair, which crowded too many people into rooms of substandard size and were lacking in toilet and bath facilities. Further, the street pattern was inefficient with very limited play area and open space.*
>
> *In addition the neighborhood contained two public elementary schools (each on sites of only seven-tenths of an acre), a parochial school, a public swimming pool, a settlement house, social meeting halls, and churches.*

IN THE METROPOLITAN REGIONS . . .

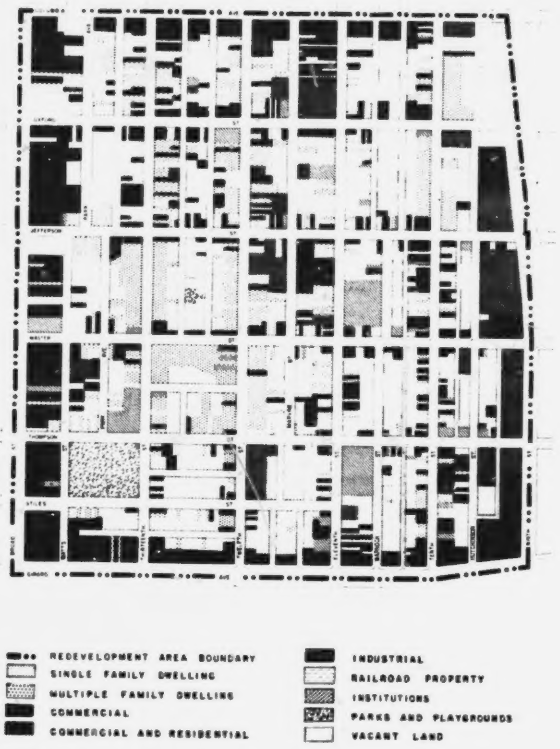
In 1950, 57 per cent of all the people in the United States—85 million of the 150 million people—lived in metropolitan areas.

The tendency for the American people to become increasingly concentrated in metropolitan areas is accelerating:

Between 1900 and 1950 these regions absorbed about 73 per cent of the country's national population increase. In the last ten years of that period, between 1940 and 1950, they absorbed 81 per cent, and in the five years between 1950 and 1955, the figure jumped still higher to 97 per cent.

If present trends continue, by 1980 the number of people living in metropolitan regions will have almost doubled—in a short period of 30 years, some 80 million residents may be added to the population of our metropolitan areas, giving them more people in 1980 than there were in the entire country in 1950.

The outskirts of a number of metropolitan areas are already overlapping those of neighboring metropolitan areas, giving rise to continuous urban regions. One such region, with a total of more than 23 million people in 1950, already extends 400 miles from Springfield, Massachusetts, to Washington, D.C. Long before 1980, this great Atlantic urban region will extend from north of Portland, Maine, possibly all the way to Atlanta, Georgia, and will embrace upwards of 50 million people.


BROAD
THIRTEENTH
TWELFTH
ELEVENTH
TENTH
HUTCHINSON
NINTH
AVE
REDEVELOPMENT AREA BOUNDARY
SINGLE FAMILY DWELLING
MULTIPLE FAMILY DWELLING
COMMERCIAL
COMMERCIAL AND RESIDENTIAL
INDUSTRIAL
RAILROAD PROPERTY
INSTITUTIONS
PARKS AND PLAYGROUNDS
VACANT LAND

SOURCE: BUREAU OF ENGINEERING, SURVEYS AND ZONING — 949 LAND USE MAPS, SANBORN MAP, VOLUME 8. BASE PREPARED FROM CITY PLAN #119.

The Redevelopment Plan undertook to restore the residential character of the community by reducing the population density, eliminating mixed land uses, locating commercial buildings near the periphery of the area, simplifying the street pattern, and providing new or improved community facilities including schools.

The plan for the schools called for enlarging the sites of the two existing public elementary schools in addition to constructing a new 1,900 pupil junior high school. Five and a half acres were added to the project to provide the site for this school, now completed. According to school officials, the junior high had been needed for years, but without the "write down" on the slum buildings the school system had not been able to acquire the necessary land. This "write down" procedure which made possible the acquisition of the land by the Board of Education, operates in the following way:

Title I of the Federal Housing Act of 1949 as Amended grants federal subsidies to city governments for urban renewal projects, to the extent of two-thirds of the total cost of the project, while the city contributes the remaining third. The city government condemns and buys land and buildings in a slum area and then resells the land to a redeveloper. (In this case a piece of the land was sold to the Board of Education as a site for the new junior high school.) The price for which the city resells the land is considerably lower than what it pays for it, the point being to encourage redevelopment by private builders. The difference between the price it pays and the price it gets when it resells the land is called the "write down."

In Southwest Temple, if the Board of Education had itself bought the sites, the land and existing structures would have cost it $1,705,000. Under the "write down" process, the City purchased the land at this price but resold it to the Board on the basis of its value as vacant land, at $321,000, with a saving to the Board of Education of $1,384,000. In accordance with Title I provisions, the federal government paid two-thirds of the "write down" and the City, one-third. (See Table III.)

The area under development.

2

TABLE **III** *Savings in Land Cost to Board of Education as a Result of Combining School Planning with Urban Renewal*

	Cost of Land and Buildings	*Sale Price to Board*	*Saving to Board*
Elementary	$ 411,000	$ 56,000	$ 355,000
Junior High	1,294,000	265,000	1,029,000
TOTAL	$1,705,000	$ 321,000	$1,384,000

NOTE: All figures rounded off to nearest 1,000.

The economics inherent in combining school planning with urban renewal extend beyond the amount of money saved by the Board of Education in the acquisition of the school site. There is a further and very substantial saving to the local taxpayer in that while the city is responsible for one-third of the total cost of a renewal project, the federal government permits it to contribute its one-third share in the form of cash and/or school buildings or other public facilities built by the city to serve the project.

In the case of the Southwest Temple Redevelopment Plan the total net project cost, including the school buildings, was $21,417,000. Of this amount the city was obliged to contribute one-third or $7,139,000. However because they spent $2,281,000 for school buildings, plus an additional $163,000 for playgrounds, they then had to pay in cash only the remainder of their obligation, or $4,695,000.

In this way the tax dollar does double duty, serving the purposes of urban renewal and school construction.

In all, this arrangement ties up blight removal, urban redevelopment, and new school buildings into an intelligent package.

Planning in the Suburbs The shift to the suburbs on the scale described indicates what has been and will be the magnitude of school building needs in the rapidly growing suburban areas, including areas which at the present time are sparsely populated.

Most suburbs immediately surrounding the cities of metropolitan regions are fully developed, but many of those located toward the outer fringes are relatively undeveloped and still have substantial space for expansion.

As in the city, so here too sound local planning involves coordination between the school system and other agencies. No school district can build a wall around itself and attempt to operate in isolation from other community conditions and decisions. It has to take into account the plans and programs of such local governmental bodies as planning commissions, housing and zoning authorities, and public works departments.

Moreover, those districts which are still small and undeveloped would be wise, especially if they lie in the path of metropolitan expansion, to keep abreast of the events that occur *outside* their boundaries in order to anticipate big changes *inside*. An extra-community

IN THE SUBURBS . . .

While the American people are becoming more and more concentrated in the relatively small number of great metropolitan regions, these regions are spreading out and becoming decentralized.

Larger proportions of people are becoming resident in the suburban rings rather than in the central cities of these regions:

In 1900 only 38 per cent of the metropolitan population lived in the suburban rings; by 1950 this percentage had increased to 42 per cent; by 1955 it was estimated at 47 per cent.

Should the trend continue, it is possible that by 1980, 60 per cent or more of the population of the metropolitan areas will be living in suburbs, while only 40 per cent will be living in the central cities.

By 1980, should the trend continue, it is estimated that 40 per cent of the entire population will be resident in suburban USA, about 26 per cent in the central cities, and the remaining third in the open country—exurbia or inter-urbia.

decision, for example, to place a national defense installation or an industrial park on a vacant tract of land will also mean large groups of personnel who require housing, roads, shopping centers, schools, and other community services. Because their activities can seriously affect what happens inside a community, the local citizens need to keep a sharp eye on the plans of such outside groups as:

- State and federal highway administrators.
- Toll highway, bridge, tunnel, and other "authorities" established by states or by interstate agreements.
- Industrial park and site developers, and industrial corporations.
- Major department and chain stores, and large new shopping centers.
- Large-scale land assembly operators, subdivision developers, housing construction firms, and mortgage underwriting companies.
- State and federal approvals of railroad service curtailment and abandonments.
- National defense agencies in regard to defense installations and defense-guided industrial locations.

The need for bold, comprehensive advance site planning is pointed up by the all too frequent examples of subdivision developments which move in and consume large land areas, leaving insufficient or poorly located school sites. A case in point, one of many that could be cited, is that of a West Coast suburban community.

THE SCHOOLHOUSE DOWNTOWN

"In the necessary and continual questioning of municipal operations, the nature and worth of a schoolhouse defy simple analysis. Though it looms as the most frequently created of all classes of municipal structures, and therefore in the aggregate is the most expensive item of capital outlay, it is burdened by having to perform more than the commonly recognized function of serving well the instruction of the young. If the schoolhouse is to produce to the maximum, it must also perform the less commonly recognized, but nonetheless vital, function of leading the city toward a better and higher plane of living.

"The schoolhouse that is only a place where children are taught during the day fulfills its primary function. Many cities are satisfied with this much and only this much. But there are those who expect the schoolhouse to serve its city in additional ways: it must serve to strengthen the whole fabric of city life by serving its whole community; its architecture should lead the neighborhood on in its own renewal; and it must help to anchor those families who are needed to keep a city in balance culturally and economically, and who are encouraged to desert to the suburbs if the city's schools are dreary and cheerless.

"Cities are organic; therefore, they must continually renew themselves. Their growth and greatness may have come about by accident or good fortune; but their decline can be forestalled only by design. Of all municipal structures, the schoolhouse, being the most numerous, holds the key to a city's physical and, indeed, sociological future.

"Certainly one could never claim that good schoolhouses alone are the answer to the country's or to the city's educational problems. But the spiritless schoolhouse can make all the problems more difficult."

Report of the Heald, Hunt, Rubin Committee on School Construction in New York City

The University of the State of New York, State Education Department, Albany, 1959.

This West Coast community, which shall be nameless, saw its residential development increasing, so it acquired a site and built a school on it. But it made no plans for the numbers of children who would need classroom space when the area reached residential saturation.

Needless to say, the school building is now too small to serve the children in the neighborhood. It is also in the wrong place. A second site and building are required, but the land is now wholly occupied by dwellings and too expensive to reclaim. As a result, many children are attending a school in another attendance area, crossing a busy boulevard or using additional bus transportation, and there is general parental disfavor.

Recently, recognizing the cost of their lack of foresight, the district completed a system-wide plan and found that 32 additional sites will be needed by the time of complete population saturation. One of these sites represented the best remaining choice to serve the area for which the "too little" school was first built. But both the "too little" and the future "too late" schools will always remain poorly located.

Over a 30-year life span for these schools, this failure to plan may cost the taxpayers of the district $1 million in transportation costs alone. The cost of the belated system-wide planning study came to $10,000.

Sub-area Planning Any attempt to project future enrollments, logical school locations, and suitable sites, and to establish priorities and schedules of construction, must recognize the variability of conditions *within the different small sub-areas of the school district.*

An illustration of this is South Kenwood, a small neighborhood in Chicago.

In the six years between 1950 and 1956, South Kenwood's population grew rapidly. It increased by about 20 per cent during a period *when the population of all Chicago rose by just over 1 per cent. Along with this, the composition of the residents changed. Its white population moved out in large numbers, decreasing by 47 per cent or almost half, while the nonwhite population shot up sharply, increasing almost seven times, by 688 per cent.*

This change in the composition of South Kenwood residents brought with it a further marked change in the age distribution, for while the total number of people increased by 20 per cent, the pre-school age children almost doubled and the youngsters of elementary school age, 5 to 14, increased almost as rapidly, by 160 per cent. In contrast to this, in the city as a whole the number of pre-school children had increased by only 1.16 per cent and elementary youngsters by 1.21 per cent.

At the same time, however, children of high school age increased at the same rate as the total population of the area. Of course, the high school population is subject to explosive growth later as the elementary school children move up through the grades. However, because of the change in composition of the new population, it might be unwise to assume that it will yield the same proportion of high school enrollments as did the previous residents.

Clearly, in planning a total building program for the entire city of Chicago, planners need to know that the proportion of elementary schools required in one small corner of the city is greater than that required for the rest of the city.

This more intensive focus on the characteristics and trends within different sub-areas brings us round once more to the questions raised in the earlier pages of this chapter. Planners must extend their questions beyond those basic ones so that different conditions in the various sub-areas of their district are adequately reflected. They must ask:

- For what parts of the school district will there be successive waves of children and accompanying classrooms needs in the elementary, junior, and senior high schools?
- Will these waves be followed by troughs leaving partly empty buildings or will some parts of the district continue to contribute about the same number to each school level?
- Which buildings will be overtaxed as subsequent waves sweep through, cresting to successively higher levels? Which will not experience this surge?
- Which buildings will gradually lose their pupils as commercial or industrial developments begin to encroach on housing?

The small area predictions required to answer such questions are especially tricky, and even the experts have tended to shy away from them. They are naturally more confident of regional, nationwide, or global forecasts which involve much larger numbers of people and more ponderous changes. In spite of the pitfalls, however, school planners must try to make estimates for specific sections of their communities.

FEDERAL AID FOR PLANNING

School building planning is a complex matter. Answers are not always available, and when they are, they are not always certain. Even when they seem unmistakably sound because they are based on meticulous calculation, there is always that vast unknown—the shape of things to come. But school boards have no choice. They must plan; at stake are the educational well-being of our children and millions of tax dollars.

Back in 1954, aware of the fact that forecasting is a technical problem for experts and many small communities cannot maintain continuous staffs of experts and consultants, the federal government stepped in to help. Under Section 701 of the Federal Housing Act, grants were provided for cities and towns with populations of less than 25,000, according to the 1950 census. The amount of these grants is equal to the amount locally appropriated for such study. Under the same 1954 Act similar matching grants were also made available to qualified regional planning agencies, or districts within states. Through Section 701, therefore, a number of school districts have already joined with local planning agencies in contracting for basic plans, including enrollment projections and future school locations.

The Federal Housing Act of 1959 provides for extension of this planning aid. Cities and towns with under 50,000 people now qualify, and counties of under 50,000 are also eligible for planning grants.

Continuous planning activities by communities and counties and by clusters of adjacent communities—with or without the use of federal matching grants—have become the *sine qua non* for providing the right number of schools of the right size in the right places at the right time with economy.

THE LIFE CYCLE OF SCHOOL BUILDINGS

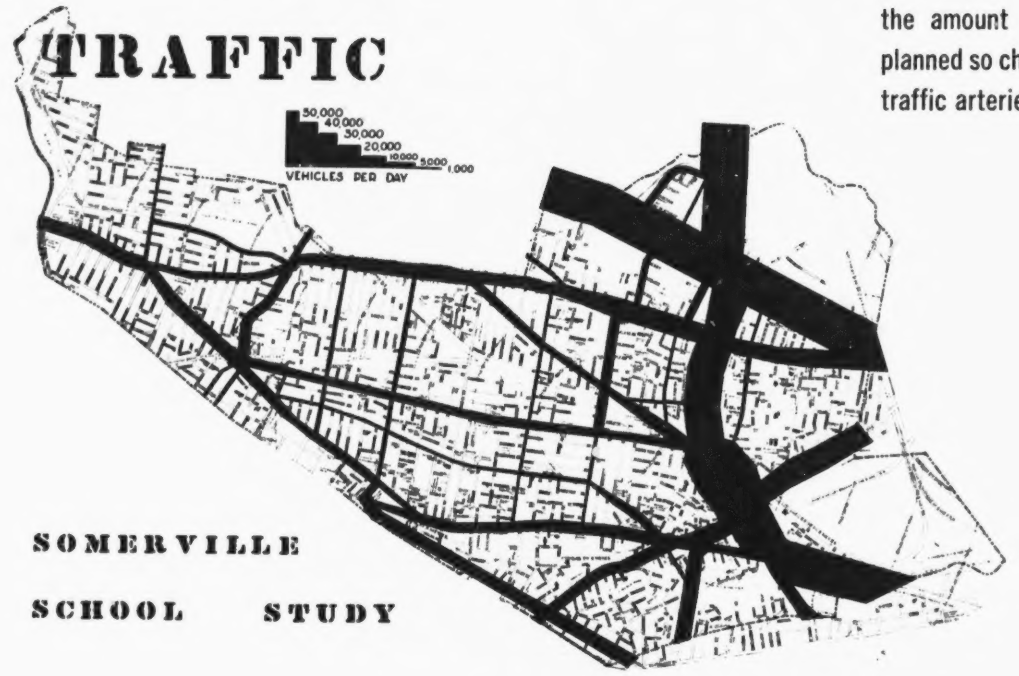
"In the life cycle of buildings, some problems may begin to occur during the first twenty years of life. Mistakes can and do occur from the start. These, however, can be minimized with care and good planning to see that buildings are properly located on adequate sites, are well designed and constructed, and make use of satisfactory materials. In our rapidly changing society, much may happen in twenty years to affect standards of adequacy in school buildings. New techniques and methods may quickly render certain parts . . . of a school building obsolete, and considerable capital outlays may . . . result. Such development is most likely to occur in two areas: service systems involving heating, lighting and plumbing; curriculums and teaching methods. . . . During this first twenty-year period in the life of school buildings—even for the next 10–15 years—capital outlays for such purposes are likely to be piecemeal and sporadic.

"After twenty years or so the school building enters a second phase of its life cycle. Deterioration has been gradually setting in as a result of use, weather and general aging. The effect is a gradual increase in annual maintenance costs as more parts of the building and its fixed equipment wear out, and as heating and operating become more expensive. During this third decade the number of defects become marked, and much of the equipment needs to be replaced. The jolting discovery may be made that one of the service systems or the roof needs to be replaced. Often this discovery coincides with the recognition that the building requires general overhauling. The brick work needs repointing, lighting fixtures ought to be replaced . . . . When faced with such problems, school administrators and school boards are inclined to see them singly; and they frequently treat them, as they do smaller problems of maintenance and repair, in a piecemeal fashion. One project after another is tackled, with an occasional lumping of projects together. Sometimes a general overhaul occurs, including both the structure and the service systems. To the extent that the latter require replacement, the most up-to-date items feasible in the circumstances are installed. Equipment required because of educational developments is added. But whatever is done is unlikely to involve complete modernization . . . . and not very well integrated into the total school plant.

"Yet the process of deterioration is not arrested, and defects continue to mount until between ages 40 and 50, or even earlier, a climax occurs. The building now begins the third phase of its life cycle . . . the cry of educational obsolescence may already have been raised. Teachers and schoolmen are quite likely to have concluded that the building as it stands no longer permits the teaching of a modern curriculum by modern pedagogical methods and that it no longer conforms to modern standards of school environment. Gradually this feeling spreads to the public at large.

"At this same time, the accumulation of symptoms of several kinds of deficiency reaches a peak. The incidence of site, location, environmental and perhaps educational inadequacy is greater among school buildings than ever before. The decision is taken to rejuvenate and modernize. The ensuing capital outlay is far greater than any made so far; frequently it is as much as all previous expenditures combined. It is seldom, however, accompanied by a longer and more careful look ahead, or by the various sorts of professional advice which are sought when new construction is undertaken.

"The decision to modernize is probably the least rational of any building decisions made by the average school board. It is usually taken with the least skilled advice and the least foresight; and it is usually based on the least amount of data. Since it aims at the same objectives as new building and involves comparable amounts



Traffic map from Somerville, Massachusetts, school study. The width of the lines indicates the amount of traffic. Schools should be planned so children do not need to cross busy traffic arteries.

of money, a comparable degree of study and of architectural, engineering and school consultant skill should enter into the decision. The question is the ratio of benefits received to money spent over the remaining useful life of the building. Whether this ratio is greater for a modernized building than for a new one, or for the old one maintained unmodernized, should constitute the crux of the decision. And this problem is seldom seriously analyzed.

"Buildings which survive the years from 40–50 exhibit relatively pronounced individual characteristics depending on the scope of modernization, and on location, site and environmental conditions which cannot be affected by improvements to the building itself. But another fifteen years of satisfactory use appears to be common. During most of this period the incidence of all sorts of inadequacy among school buildings remains well below the 40–50 year peak.

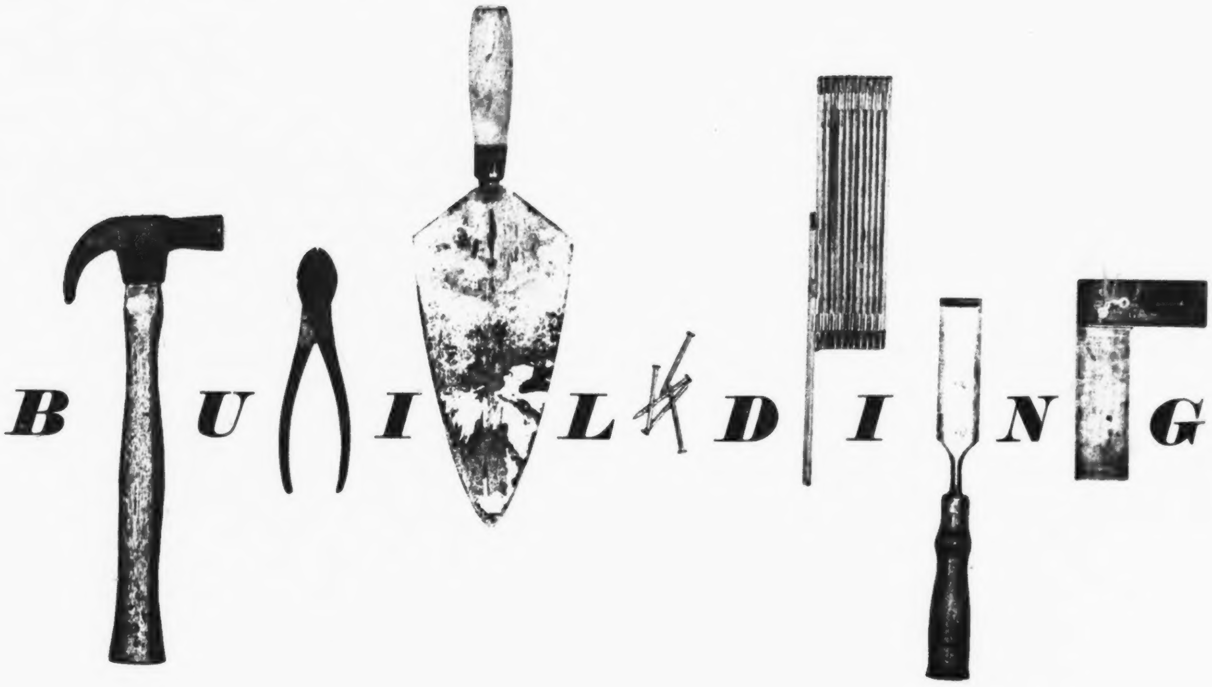
"After about age 60, however, educational deficiencies begin to mount once again. Somewhere between the ages of 50 and 70 the majority of schools are abandoned. For the rest, the pattern of steadily growing maintenance costs is repeated or—what amounts to the same thing—a steady decline occurs in the serviceability of the building. Increasing major repairs will be needed. More frequent breakdowns in service will occur. Frequently it will be contended that the building is obsolescent, but arguments based on financial considerations will often prevent its abandonment and replacement. Frustrated discussions will often result in an unenthusiastic decision neither to replace or remodel the old school but to maintain and operate it until such time as it can be replaced.

"Thus around the age of 60, the deficient school which has survived will usually last only 10–20 more years. It becomes increasingly obsolescent educationally. Site, location, environment, and service systems become worse and worse. Only the structure continues to be kept in good shape. Acknowledged to be unsatisfactory, it does not deserve further major expenditure. It may be scheduled for retirement, but as long as it continues to serve as a school its upkeep and lack of serviceability will cost the community dearly.

"Schools of the future by no means need to follow the life cycles of past and existing schools. If a building is properly constructed and well maintained, structure and fire hazards should present no problem. Proper planning can practically eliminate inadequacies of site and physical environment, and can go far towards preventing a school from becoming poorly located with respect to school population and organization. . . We can do a great deal to make school buildings adaptable to future technological changes in service systems and future changes in educational requirements. This does not mean that we should try to go on using our school buildings indefinitely. Adaptability has its limits, and unforeseen changes are bound somewhat to upset the best of planning. What it does mean is that . . . we can eliminate some problems, cut down the magnitude of others, plan for modernization and try to foresee the need for abandonment as far in advance of the actual event as possible. If we adopt such a course, we can to a considerable extent control the life cycle of school buildings in the interest of obtaining the best possible facilities for our everchanging educational requirements at lowest long-run cost."

Economic Planning for Better Schools:
A. Benjamin Handler
A Department of Architecture Research Publication;
University of Michigan, Ann Arbor, Michigan

BUILDING



QUANTITY × UNIT COST = THE COST OF BUILDING

What is the dollar cost of a schoolhouse? Basically, it is a problem of multiplication. Take the quantity of school (in square feet) times unit cost in dollars (so much per square foot) and you have it. While this approach is oversimplified, it nonetheless makes the subject intelligible. And intelligibility is badly needed in regard to school costs. Both the friends and foes of the American schoolhouse have contributed towards making a complex matter almost incomprehensible.

What are the elements that contribute to the two factors of our equation, quantity × unit cost?

Quantity is based primarily on enrollment and educational program. While the architect may save some space by a design which cuts down on corridors or service areas, the basic decisions which affect space are program decisions and school enrollment.

These will be program decisions. Is an auditorium needed, and if so, must it accommodate the whole school, or only part of it? If an elementary school, will there be a separate library, playroom, art room, or music room? Will a separate auditorium and cafeteria be needed, or will a combination of the two be a satisfactory compromise? How large will each classroom be? The decision (pedagogical not architectural) as to how many pupils are to be assigned to each classroom will also affect the space per pupil. (A proportionate amount of space is rarely provided when the number of pupils per class increases—often classroom sizes remain the same.) If a secondary school, the questions of academic versus vocational space (the latter ordinarily requires more square feet per student), and the size of the auditorium, gymnasium, and cafeteria will all affect total area. A laboratory requires more square feet per student than a classroom.

Mack

In short, the answers which will have the greatest effect on the amount of school to be built are *educational, not architectural*. These answers must be arrived at after considering many factors other than building costs.

While design efficiency—the proportion of usable educational space to total space—will be an important consideration, *it will be less significant than the educational decisions.*

Another important ingredient in the equation will be the climate. In areas where the outdoors provides a reasonable road from room to room, substantial savings in quantity of building can be achieved. In areas where, for climatic or cultural reasons, the hallways must be enclosed, these savings are impossible.

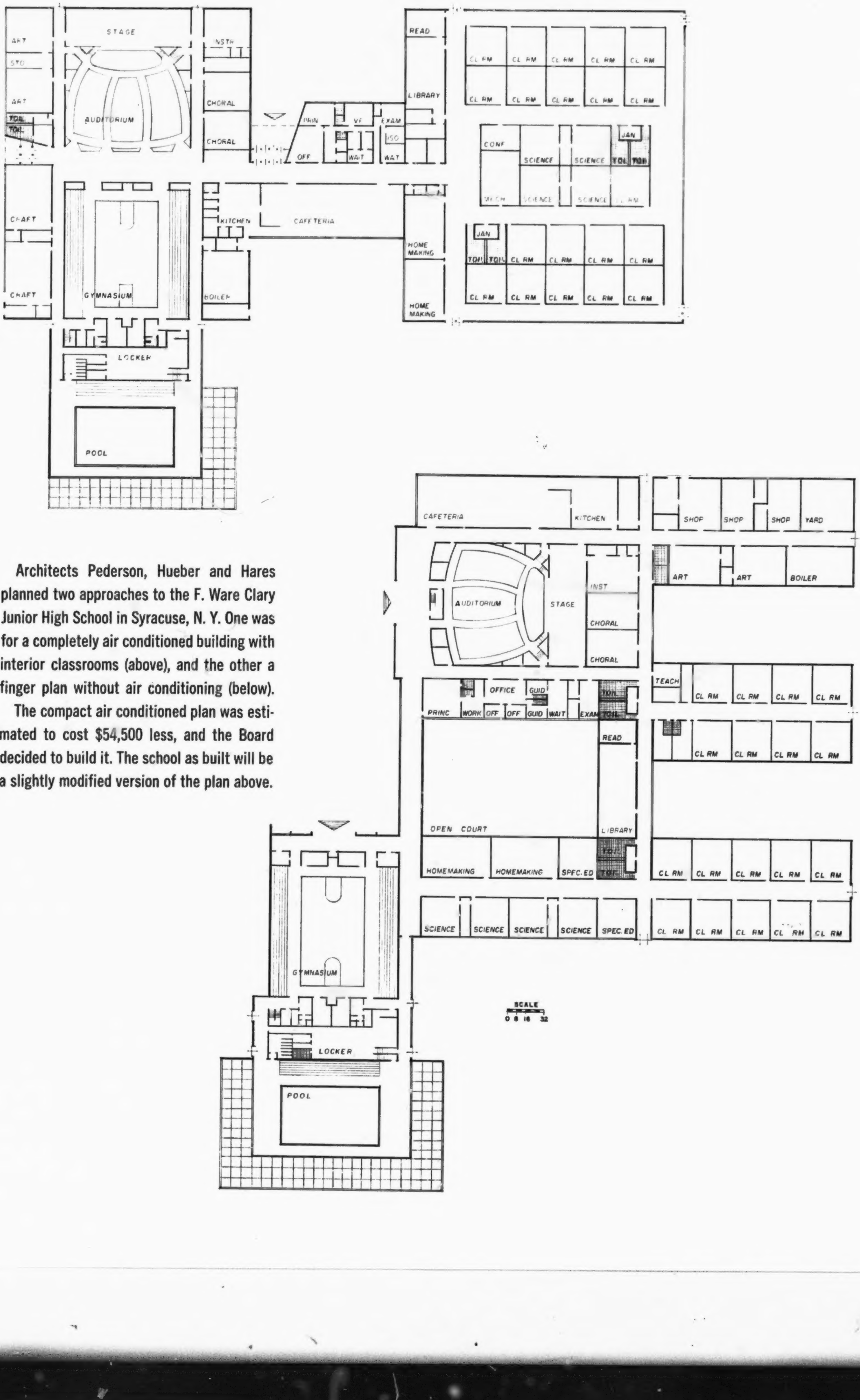
The question of *unit cost* is more complex. A terrazzo floor is more expensive than an asphalt tile floor. It costs more but it also lasts longer. Better hardware, three rather than two hinges per door, solid doors rather than hollow core doors, partitions between rooms which are acoustically adequate for speech privacy, partitions which can be moved by a few men with screw drivers to accommodate a changing program, all these are things which add to the unit cost and quality of the school. Some things only add to unit cost, not quality. For example, foundations on a difficult site will add to cost. They contribute nothing to lowering future maintenance. Yet the site may be the only appropriate one available. Excessively costly detailing and the use of inappropriately high quality material for a part of a building which is inconsistent with the quality throughout add to the cost, but contribute little to over-all quality.

There are design factors which tend to confuse the question of unit cost. Compactness of structure is an example. Exterior walls are expensive. All other things being equal, the cost of the building will be lower if the proportion of exterior walls to area is lower. Of course all other things are not equal. The square is the rectangular building with the lowest proportion of exterior wall to area. But if it is large enough, it leads to windowless rooms and to air conditioning, which is comparatively expensive. A recent study in Syracuse, valid only for that school in that area, led to a compact school, air conditioned, with interior classrooms. In this case it proved to be more economical than a spread-out plan with windows in every classroom. This illustrates the problem of the decisions—basically value judgments—that must be made in planning a school. Are air conditioning, a compact plant, and interior classrooms preferable to a spread-out plant, windows in all classrooms, and no air conditioning? They thought so in Syracuse, but do you?

A Look at Space and Unit Costs

What are the things that make up the second half of our equation, the unit cost of a schoolhouse—the $14 or $20 a square foot which is thrown around in magazines and newspapers, in town meetings and school board meetings, in each of the 50 states?

EFL surveyed 100 secondary schools, built during the period of 1956 to 1958. The schools were sorted into geographic regions. Area per pupil as well as unit cost was computed. Seventy-two of these schools had data available in sufficiently comparable form for inclusion in the fol-


STAGE
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GYMNASIUM
KITCHEN
CAFETERIA
BOILER
HOME MAKING
HOME MAKING
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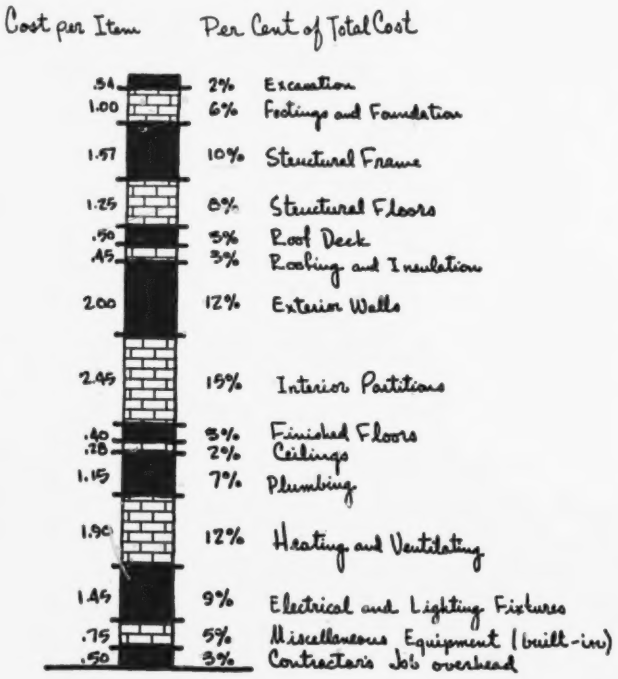
Architects Pederson, Hueber and Hares planned two approaches to the F. Ware Clary Junior High School in Syracuse, N. Y. One was for a completely air conditioned building with interior classrooms (above), and the other a finger plan without air conditioning (below).

The compact air conditioned plan was estimated to cost $54,500 less, and the Board decided to build it. The school as built will be a slightly modified version of the plan above.

lowing charts of unit cost. The median square foot cost of the 72 schools was $15.99. Table I shows the elements which make up this unit cost.



Median Cost per Square Foot of 72 Schools Surveyed by E.F.L.

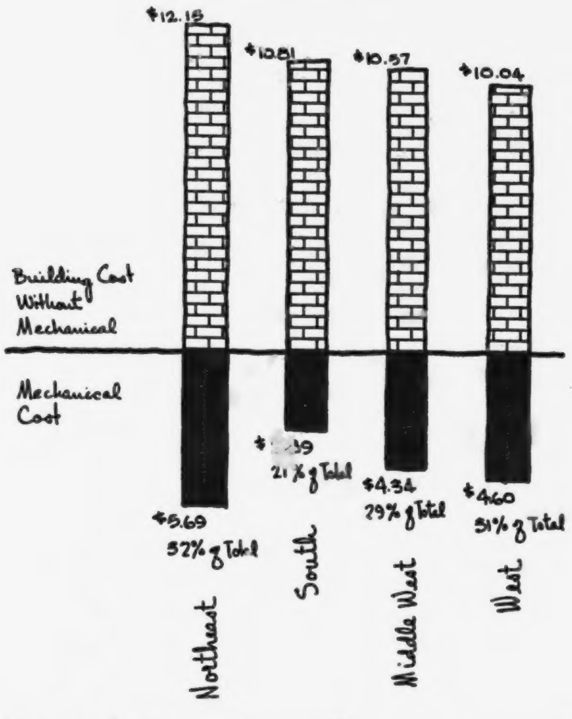
TABLE I *Median cost per square foot of 72 schools surveyed by* EFL

	Cost per square foot of Gross Building Area
Excavation	**$ .34**
Footings and Foundation	**1.00**
Structural Frame	**1.57**
Structural Floors	**1.25**
Roof Deck	**.50**
Roofing and Insulation	**.45**
Exterior Walls (Masonry, windows, glass panels)	**2.00**
Interior Partitions	**2.45**
Finished Floors	**.40**
Ceilings	**.28**
Plumbing	**1.15**
Heating and Ventilating	**1.90**
Electrical and Lighting fixtures	**1.45**
Miscellaneous Equipment (built-in)	**.75**
Contractor's job overhead	**.50**
	$15.99

NOTE: All costs adjusted to the 1959 *Engineering News Record Index* to account for inflationary and regional differences due to year built and location.

This table collects all the costs for all the elements and trades of the building divided by its total area. Examining this table may indicate why it is so difficult to keep building costs down. Obviously there is no room in such figures for dramatic savings. *The road to economy in unit cost is by careful attention to every single detail of the building,* to each of the figures which makes up the $15.99.

Mechanical costs—wiring, heating, ventilating, and plumbing—make up a very substantial element of the total cost of the building. Not unexpectedly these figures vary substantially from region to region within the United States. Climate affects not only the size of the building but also the unit cost. Table II illustrates the geographic variation of mechanical costs, from 32 per cent of total cost in the Northeast and 31 per cent in the West to 21 per cent in the South. To look at it another way, mechanical costs in dollars per square foot in the Northeast were almost double the figures for the South.



Median Cost per Square Foot by Geographical Area

TABLE II *Median Cost Per Square Foot by Geographical Area*

	Building Total Cost	***Mechanical Cost***	***Building Cost Without Mechanical***
Northeast	17.84	5.69	12.15
South	13.70	2.89	10.81
Middle West	14.91	4.34	10.57
West	14.64	4.60	10.04

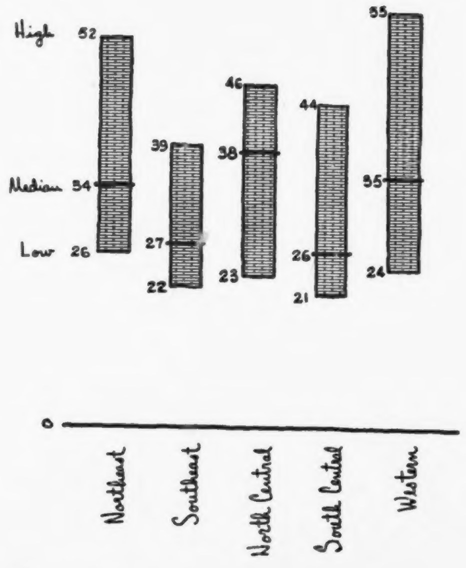
EFL's survey also examined the question of quantity. Space was classified arbitrarily as classroom area, auxiliary area, and service and structure area. The planned capacity of each school was accepted as reported.

Classroom Area

The classroom area, including shops, laboratories, homemaking, industrial arts, and other specialized rooms as well as academic units, ranged from 21 to 55 square feet per pupil as shown in Table III. The regional medians range from 26 square feet per pupil in the South Central to 38 in the North Central area. If your building departs radically from these medians, ask why. It may be too large or too small.

TABLE III *Range and Median of Classroom Areas (square feet per pupil by regions)*

	Low	*Median*	*High*
Northeast	26	34	52
Southeast	22	27	39
North Central	23	38	46
South Central	21	26	44
Western	24	35	55



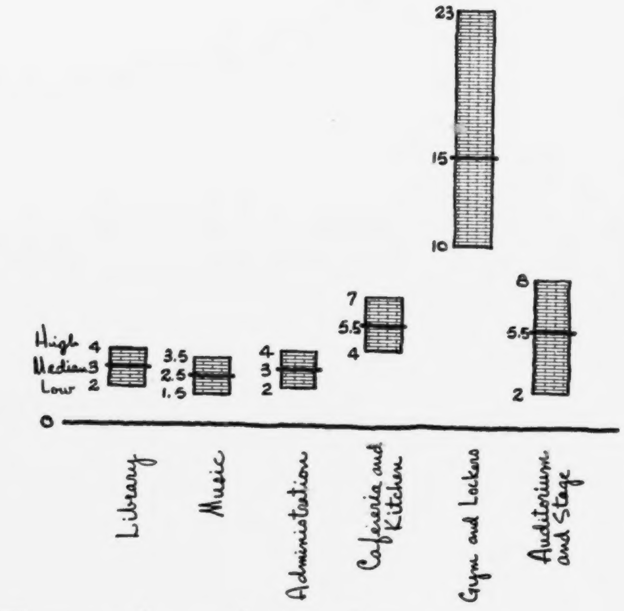
Range and Median of Classroom Areas
(Square feet per pupil by regions)

Auxiliary Area

The auxiliary area includes the library, music rooms, administration, cafeteria, gymnasium, and auditorium. The range and the median space per pupil for each of the auxiliary areas are indicated in Table IV.

TABLE IV *Range and Median of Auxiliary Areas (square feet per pupil)*

	Low	*Median*	*High*
Library	2.0	3.0	4.0
Music	1.5	2.5	3.5
Administration	2.0	3.0	4.0
Cafeteria and Kitchen	4.0	5.5	7.0
Gymnasium and Lockers	10.0	15.0	23.0
Auditorium and Stage	2.0	5.5	8.0



Range and Median of Auxiliary Areas
(Square feet per pupil)

Note the substantial contrasts between low and high here, particularly in auditoriums, from 2 to 8 square feet per pupil; in gyms, from 10 to 23 square feet per pupil (the latter area begins to approach the median square feet per pupil for classrooms), and in music from 1½ to 3½ square feet per pupil. In fact in all categories there is a substantial range. The highest ranges may occur when a building is built in two stages, the first stage including a gymnasium, for example, large enough to accommodate a later addition of classrooms. Again, if you depart radically from the medians, is there a clear and compelling reason?

Service and Structure Area

Service and structure area consists of those spaces needed for corridors, general and custodial storage, toilet rooms, stairways, boiler rooms and mechanical equipment, and the actual floor space occupied by the walls of the building. Climate and culture permitting, the ingenuity and the industry of the architect can keep these areas to a minimum. Minimal service areas do not affect the educational facilities. *Hence the most painless road to economy in space is careful scrutiny of the service spaces.* The range and median spaces for these areas in the survey are shown in Table V.

TABLE V *Range and Median of Service and Structure Areas (square feet per pupil by regions)*

	Low	*Median*	*High*
Northeast	25	38	84
Southeast	.5	15	43
North Central	19	45	75
South Central	6	28	43
Western	9	24	48

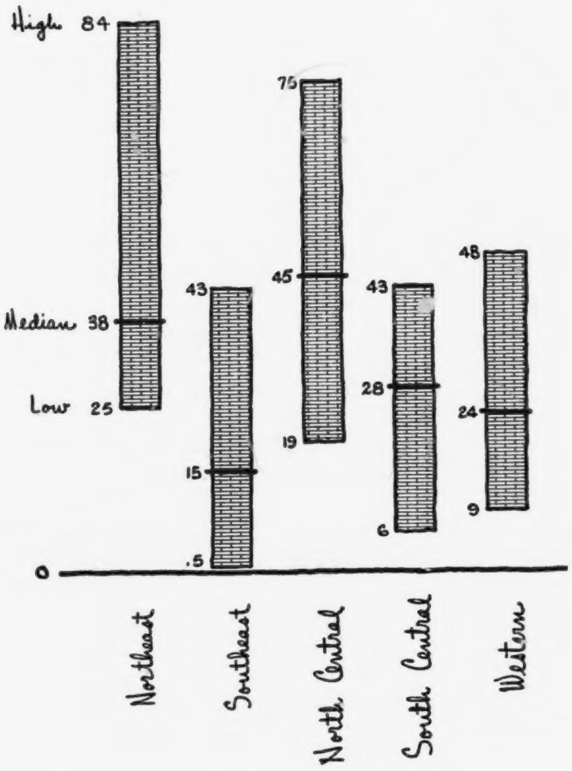
The substantial regional variations here—in particular between 15 square feet per pupil in the Southeast area and 45 square feet in the North Central area reflect in part the differences in climate, i.e., whether the outside is often used as corridor space, and in part the additional auxiliary areas which require additional service and structure areas. Table VI, summarizing the findings of the EFL survey, gives the total median square feet per pupil allotments as well as the median for classroom, auxiliary, and structure and service areas. Note the substantial regional variations in over-all space. In the North Central region over-all space is 56 per cent higher than in the Southeast.

TABLE VI *Median Space (square feet per pupil by regions)*

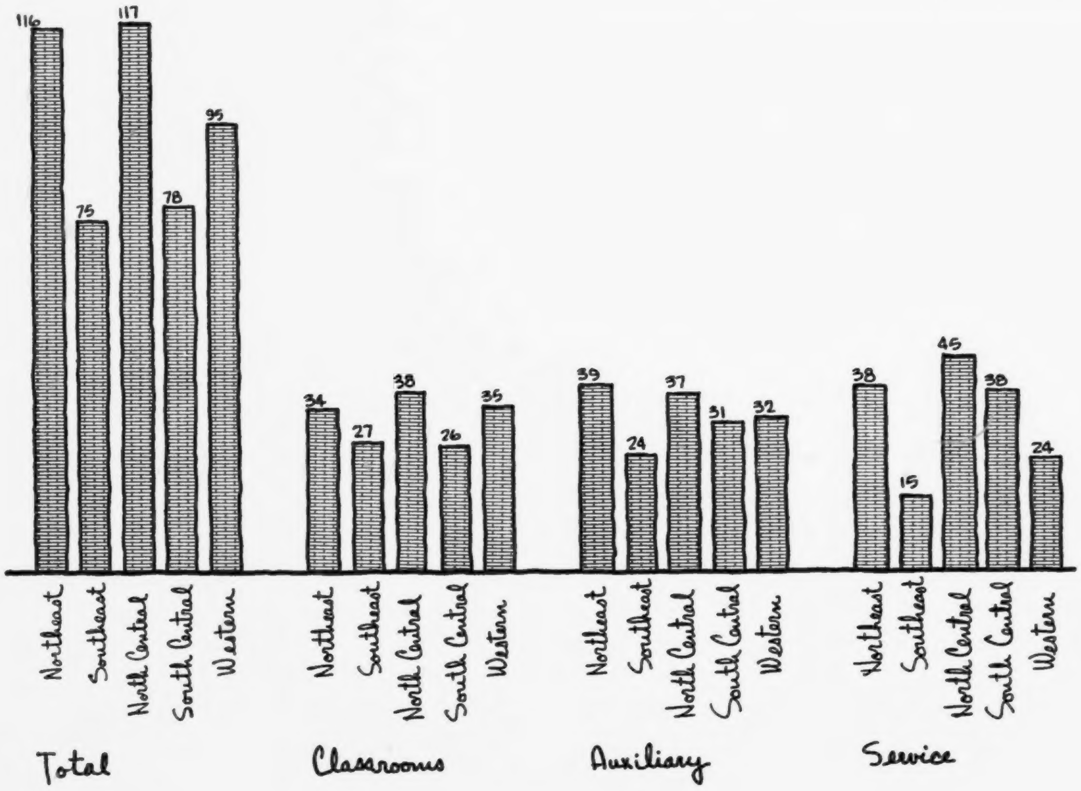
	Classrooms	*Auxiliary Rooms*	*Service*	*Total*
Northeast	34	39	38	116 *
Southeast	27	24	15	75
North Central	38	37	45	117
South Central	26	31	38	78
Western	35	32	24	95

* The totals shown here are the medial totals and are not the sum of the medians of each category. For this reason the columns will not add across.

If any one conclusion emerges from EFL's survey, it is that area (per pupil) is at least as great a factor as unit cost in accounting for the most dramatic contrasts between the costs of schools.



Range and Median of Service and Structure Areas
(Square feet per pupil by regions)



Median Space
(Square feet per pupil by regions)

Before going on to look at the elements which make up the cost of the school building, let's look at the process of decision making.

Designing a school is a joint venture, or should be a joint venture, among architect, educator, and the community (as represented by the school board). An excellent summary of the steps in designing and constructing a building was proposed by Philadelphia architects Nolen and Swinburne, who have allowed us to reproduce it on page 70.

The Architect

Choosing an architect is one of the most critical steps the school board must take. There is no simple rule of thumb to say how to select a good one rather than a bad one, or an excellent one rather than a good one. But don't decide around a conference table after a ten-minute interview. Visit schools, talk to previous clients, discuss your problems at length with prospective architects. Remember you are looking for a man who combines esthetic sensitivity, engineering knowledge, cost consciousness, and perceptiveness in regard to the educational program. It is a hard combination to find.

General rules regarding small firms, large firms, and previous school experience or the lack thereof, are less important than the quality of the architect's work to a school board selecting among a number of architects. Remember one thing in choosing an architect. The best ordinarily costs no more than the worst. So get the best for your job and don't spare effort in choosing him. *No single step will be more important in seeing that you get the most for your school building dollar.* The difference, according to estimates made in a New York State Department of Education study, can be as much as five per cent of the total cost of the building.

Educational Planning

Don't expect the architect to make the educational decisions necessary before planning the building. He may help, but it is not his job.

The school's ability to define with all possible precision such factors as these is necessary for the architect in his planning:

- The number and ages of children to use the building at various times in its lifetime, including the likelihood of future expansion or contraction.
- The teaching methods.
- The equipment to be used, i.e., television, projection equipment, etc.
- The organization contemplated, i.e., will the school be subdivided into little schools or clusters of classrooms? If it is to be subdivided, what way? Why?
- Objectives must be clear in regard to the large spaces, i.e., how much auditorium and for what—drama, lecturing, school meetings, community use? What percentage of the children must be seated at once in the cafeteria? Will they dine, or will it be mass feeding? What kind of physical education program is contemplated?

The Steps in Building

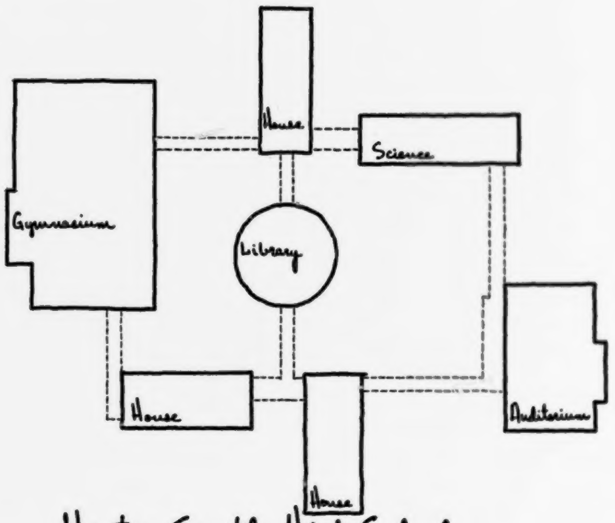
Owner	Architect	Owner and Architect
1 Seeks architectural services		
		2 Preliminary conferences
		3 Owner/Architect agreement
		4 Establish building program
		5 Set production time limits
	6 Program analysis	
	7 Schematic designs	
8 Approves schematic documents		
	9 Preliminary drawings	
	10 Preliminary specifications	
	11 Preliminary estimates	
		12 Conference on preliminaries
	13 Revisions to preliminaries	
14 Approves preliminary documents		
15 Authorizes final documents		
16 Approves special consultants, if any		
		SPECIAL: 17 25% of fee now payable
	18 Final working drawings	
		19 Conference on specifics
	20 Final specifications	
	21 Final estimates	
		22 Set construction time limit
		23 Conference and review
	24 Revisions, if required	
		SPECIAL: 25 Review by City, State and Federal groups
		26 Conference and acceptance
27 Approves final documents		
		SPECIAL: 28 50% of fee now payable
		29 Select contractors for bidding
	30 Issues documents for bidding	
31 Receives bids		
		32 Bid tabulation and review
	33 Advises on contract award	
34 Awards contract		
	35 Assists in execution of contract	
36 Executes contract		
	37 Approves bonds and insurance	
38 Arranges for waiver of liens		
	39 Issues proceed letter to contractor	
		40 Field construction begins
	41 Supervises construction	
	42 Prepares field inspection reports	
	43 Reviews and approves shop drawings	
	44 Inspects and approves samples	
	45 Prepares monthly certificates	
46 Pays construction costs monthly		
		47 Review construction reports
		SPECIAL: Emergencies
		SPECIAL: Construction delays
	48 Prepares and signs change orders	
49 Countersigns change orders		
		SPECIAL: 50 25% of fee pro-rated
	51 Receives special guarantees from contractor	
	52 Makes final inspection	
53 Receives release of liens		
54 Makes final payment		
55 Accepts building		
56 Assumes maintenance		
		57 Celebration

- What will be the subject matter and how will it affect the spaces, i.e., science and language laboratories, vocational programs, music programs, home economics, etc.?
- What will be the sizes of groups to be brought together for instruction? Will there always be 30 or 35 students and an instructor? Or will there be individual work space and spaces for groups of 15, 30, 50, 100, or more?
- What facilities are needed for teachers? Will they need office spaces for teaching teams, departments, etc.?
- What is the need for administrative and guidance facilities? Should they be centralized or decentralized?

In short the school board must know the type or kind of facilities to be provided and the numbers to be accommodated in each. These two sets of requirements determine two-thirds of the size of the building.

With an architect and a program—at least a preliminary program—it is possible to begin designing the school.

The nature and organization of the school program are basic in determining over-all design. It is logical when decentralizing a school into three "little schools" to build it that way, design flowing from program. The Newton South High School was planned as three subunits with certain shared space where such space was too costly to duplicate. The library was to be the center of the school. The general plan reflects this.

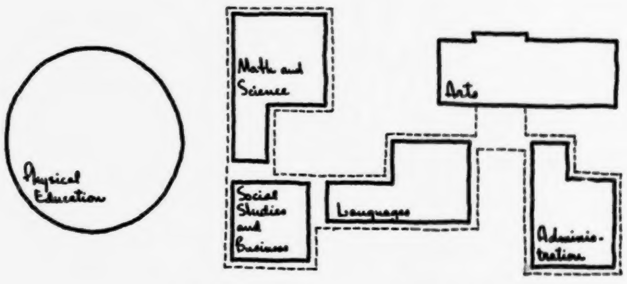


Newton South High School

Another recently constructed school, the Wayland Senior High School, was academically oriented so that each curricular division was self-contained. Again the community's educational logic—they wanted a high school collegiate in spirit—found expression in the plan. The field house was designed so that physical education would be more than the typical basketball-oriented program housed in a gymnasium basketball court. It also serves for town meetings.

A school—being a place for learning, a place where things happen—should reflect in its over-all design the process it contains. If it does not it cannot be truly economic; indeed it may only be cheap. But it may accommodate its process in a number of ways.

Class Size and Classroom Size Class size and classroom size are two of the most important questions every school board must face in planning a school. An increase in class size is not ordinarily accompanied by an increase in classroom size. Consequently, an increase in class size means less school building to buy. However, the building is but one of the issues involved and not the most important.



Wayland Senior High School

In the 1957–58 school year elementary classes in urban areas averaged 30.1 pupils (median 30.7). Elementary classrooms built or planned since 1940 in twenty cities had a median area of 888 square feet according to a 1950 survey by Engelhardt, Engelhardt and Leggett (from *Planning American Elementary School Buildings*, F. W. Dodge, 1953). These elementary rooms ranged from 660 to 1,350 square feet. Kindergarten rooms were substantially larger, ranging from 960 square feet to 1,980 square feet with a median of 1,150.

Ordinarily, because of the somewhat more sedate activities which occur therein, high school classrooms are smaller than elementary school classrooms. Today in better schools they are likely to be 800 to 850 square feet for average academic rooms.

Most school authorities would equate high quality education and small classes in the elementary school and, to a lesser extent, in the secondary school. But there is gradually emerging a new way of looking at class size and its space, as the concept of the self-contained classroom gives way to the teaming of teachers and rearrangement of pupils from time to time during the day in a variety of group sizes. These may range from individual study, to seminar, to standard class, and to lecture demonstration groups. The ratio of staff to student body rather than class size becomes the important criterion, particularly in the secondary schools.

The advent of instruction by television gives further impetus for looking at over-all faculty-student ratios rather than the number of children in the presence of one teacher in one uniform space called a classroom. Basically the determination of class size is a value judgment. The subject is surrounded by opinion, conflicting philosophies, and conflicting cultural habits. While the amount of research on class size is substantial, it is not definitive or conclusive. But those concerned professionally with education will generally agree that if the child is to compete for the teacher's attention all day in the ratio of 1 among 35, he prospers less well than if the uniform ratio is 1 to 25. But the ratio of 1 to 25 is, of course, more expensive than 1 to 30 or to 35. This poses a dilemma for the school board budget and frequently an unhappy compromise between the desire to increase teachers' salaries and the desire to keep class size low. Out of this dilemma comes in part the reason why many schools are now employing a variety of sub-professional personnel, teaching assistants, clerks, aides, and so forth. The best exposition of this can be found in two recent publications of the National Association of Secondary School Principals, *Images of the Future*, and *New Directions to Quality Education.*

The Site

Some of the factors regarding site selection have been considered in Chapter III as they affect planning. While early site selection and proper placement of sites in regard to noise, traffic, parks, houses, future growth and decay are the most important factors in regard to site selection, the influence of the site on building is not to be ignored. One community recently spent over $400,000 on fill for a new high school (the equivalent of roughly 25,000 square feet of finished building). It was a choice made after agonized rejection of more dubious alternatives.

The site may also affect a building in other ways which appear to be building costs rather than site development costs but actually reflect the influence of site on the design of the building. The site may influence the height, shape, or placement of the whole building. Some of the ways in which a site can influence costs are shown in the following comparison of two school sites quoted from *Economy Handbook*, published by the New York State Commission on School Buildings, November, 1953.

The following table gives a comparison of the estimated cost of site, site development and building placement as reported to a school board by engineers engaged to study two proposed sites. It emphasizes the necessity of having an architect or engineer make a careful *investigation of any site being considered. It will be noted that despite the fact that Site B was a gift, the estimated cost of Site A before test borings had been made proved to be $5,050 less than the cost of Site B. However, the test borings revealed that an estimated additional expense of $30,000 would be required for piling on Site A. Thus, if the school board had purchased Site A as it had planned, the community would have been required to spend an additional sum estimated at $24,950.*

TABLE VII Comparison of Estimated Costs

	Site A	*Site B*
Clearing and Grubbing	$ 100.00	$ 1,500.00
Demolition of Old Building	1,200.00	
Excavation and Embankment	5,000.00	7,000.00
Underdraining Athletic Field		3,200.00
Storm Drains	300.00	8,000.00
Gravel for Roads, Parking Areas, and Athletic Fields	1,000.00	7,500.00
Cobble Gutter		950.00
Sodding New Slopes		1,800.00
Driveways and Parking Areas	8,200.00	9,500.00
Supply and Place Topsoil	2,800.00	600.00
Water Supply	7,600.00	11,200.00
Sewage Disposal	4,500.00	4,500.00
Total for Developing and Placing Building	30,700.00	55,750.00
Purchase Price	20,000.00	Gratis
Total Estimated Cost—Nov. 1, 1952	$50,700.00	$55,750.00
Additional Cost for Piling as Indicated by Test Borings on Nov. 10, 1952	30,000.00	None
Total Estimated Cost—Nov. 10, 1952	$80,700.00	$55,750.00

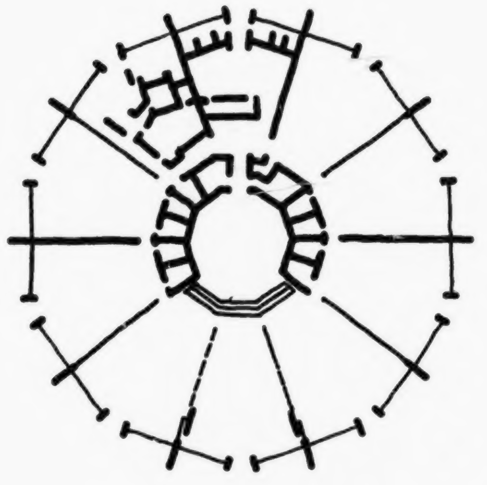
Determining the adequacy of a site and estimating the cost of its development require the services of an architect, an engineer, a contractor, or all three. The architect and engineer can advise the board on many of the cost items the site may impose, not the least of which may be the type of structure it necessitates. They can also select a pattern of test borings for soil and subsoil analysis. It can be laid down as a fixed rule in almost all areas that no site should be purchased without first having test borings made. Sites have been purchased only to find out too late that they were ancient bogs long ago filled in or that a seemingly excellent surface was honeycombed with abandoned mine shafts. The cost of providing deep footings or of floating a building because of poor foundation conditions need not confront the careful board except as a deliberate choice.

Once the site is purchased the site plan should be studied in more detail, testing a variety of building locations, shapes, and orientations, and estimating for each how well the land is used and how effective the contour of land and the locations of trees are in helping to reduce the amount of money spent on heating, cooling, ventilating, and on lighting requirements and window blinds. Trees are perhaps the most important landscape element. They may provide shelter from the sun as well as wind funnels to circulate the air in hot climates or (if evergreens) will serve as windbreaks against the chilling blasts in colder regions. Trees already on the site should be preserved wherever possible. Landscaping

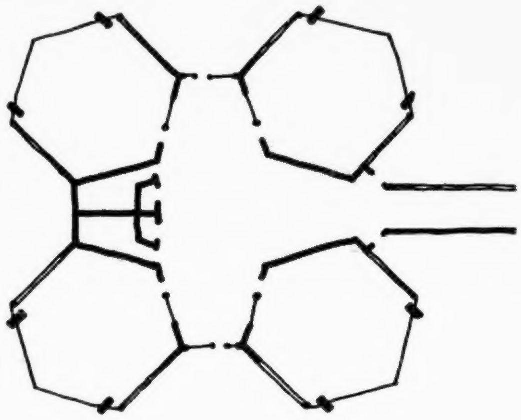
ON SUN SHADES ET AL

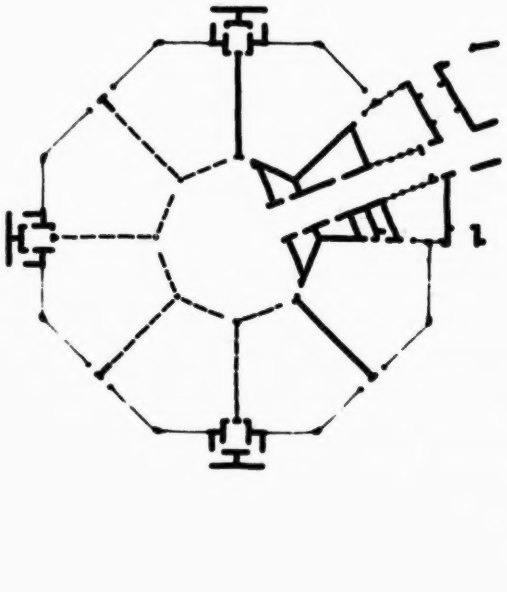
Shading is a necessary nuisance; that is, a nuisance to operate, impossible to keep clean, expensive even at its cheapest (considering the frequent replacements). It often ruins the clean simple lines of the classroom interior which were so attractive in the architect's rendering. It is hard to tell which is worse: venetian blinds, which at least allow ventilation when drawn, or roller shades, which at least allow a shading sufficient for moving picture projection, or draw curtains, which at least can be made decorative and add to instead of detract from the attractiveness of the room. Shading has been the architect's despair for long enough to have led to such inventions as placing the sun control device outside of the window: devices such as brows, overhangs, control vanes (vertical mostly, operative sometimes) or the latest, a kind of tracery screen, surrounding the windowed walls of the building like an outer shell, made of metal, wood, or masonry units. The first cost and maintenance of all such devices often far exceed their utility. The dreary horizon of mechanical artificiality which they sometimes set between the window and the outside world denies the very reason for which the window was installed, namely to see through it to the outside world. They often tend to impart the feeling of being in a prison or in a cage in the zoo.

There is, however, one variant of the screen which combines all its advantages with a minimum of its drawbacks. It is pleasing to look at from the inside and from the outside, fully automatic, and self-adjusting to the seasons. It opens to a hardly noticeable tracery in the late fall, when sunlight begins to change from bane to blessing, and closes again with the coming of spring. It is self-maintaining and self-replacing. It repaints itself at no cost every year. It is made by the oldest manufacturer of building materials, who spends nothing on advertising, and depends entirely on the promotion of poets and painters. Planting offers possibilities for sun-control not available in any other system, hardly explored yet, and rarely used fully. A good landscape architect, made partner in design, can contribute much.



Cluster plans make it possible to accumulate corridor areas so they can be used for educational purposes, and save space too.
Examples (top to bottom):
Belaire School, San Angelo, Texas. Caudill, Rowlett, and Scott, architects.
Heathcote School, Scarsdale, New York. Perkins and Will, architects.
Proposed Hilltop School, Niskayuna, New York. A. B. Sziklas, architect.





of the site should include such additional plantings as may be needed.

If future additions are planned—and frequently they are constructed even if not originally anticipated—the site plan should reflect this so that expansion will require a minimum of land alterations.

Design

Design is almost everything. It affects the quantity of the school and determines the unit cost. It is, of course, the basis of whether the school functions and adapts to its task, whether it graces the neighborhood, pleases its occupants, and continues to work with minimal maintenance, or whether the schoolhouse is a failure.

Because this is a book about school costs, we will emphasize those aspects of design most concerned with costs. (The question of design and its relation to esthetics has been discussed with both beauty and precision in Walter McQuade's *Schoolhouse*, Simon and Schuster, 1959.)

How High? Design affects the over-all shape and form of the building. Is it to be one story or two—a single building or several? These decisions will be important. They will also affect all subsequent decisions.

The old one-story versus two-story debate still rages but finding one consistently more economical than the other does not seem to be possible. The weight of opinion seems to be that you can save 3–5 per cent with a one-story building in most cases, but exceptions are not uncommon. Probably the critical factors in making the decision should be:

SIZE Some schools, particularly secondary schools, are so large as to be unmanageable on one floor.

SITE The amount of site available or amount needed for athletics may mean two stories or more.

SCALE The desire to keep a school in scale with the homes around it and to keep the transition from home to school as gentle as possible for elementary students may dictate one story.

CLIMATE Where the climate is such that using the outdoors for teaching is common and where its use for corridors is a sensible economy, a one-story building may be the logical choice.

In the report of Rensselaer Polytechnic Institute to New York State, *Potential Economies in School Building Construction* (published by the University of the State of New York, 1958), the principal advantages claimed for each were as follows:

"**FOR THE SINGLE STORY:** Elimination of expensive and hazardous stairways

More flexibility in layout, permitting space requirements and site conditions to be met with a minimum of waste

Lighter structural design loads, resulting in reduced foundation requirements, a consideration of particular importance in areas of poor sub-soil conditions

Possibility of using cheaper non-fireproof construction that would be prohibited in a multi-story design

Generally reduced cost of maintenance of window areas and exterior walls by eliminating the need for scaffolding and extra risk insurance for workmen.

"**FOR THE MULTI-STORY:** Smaller square footage of ground coverage resulting in reduced lineal footage of foundation; a consideration if site is rolling or otherwise 'difficult.' (The obvious problem of site size will not usually be a factor, as sufficient acreage should be purchased to permit either single or multi-story construction.)

Reduced roof area affecting heat loss and maintenance costs

Lower plumbing costs, with more compact (stacked) toilet layouts

Shorter runs for piping, ductwork and conduit

Reduced heating costs due to lower over-all heat loss"

To the extent that the one-story design provides for rapid exit to the outdoors, safety for the children can be achieved with much less fireproof construction (codes permitting) than required in multi-story schools. Protection of the building against fire loss would require more nearly equivalent fireproofing.

Designs for larger schools often incorporate both one-story and two-story units, and on some sites split-level design has been used to advantage.

The Arrangement of Spaces The arrangement of spaces within the school is important in determining how successfully the school works as well as how economical it is in its use of space. Among the elements to bear in mind in considering various arrangements are:

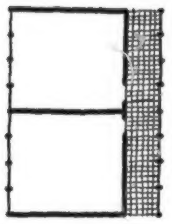
USABLE SPACE The proportion of space going into usable areas as against service areas and corridors is an important economy factor.

EXTERIOR WALLS The length of exterior walls in proportion to interior space will have a substantial effect on cost. Exterior walls are expensive. Any plan which adds *unnecessarily* to exterior walls is uneconomical. However, there are many buts in this situation. First, the least exterior wall in proportion to area is in the circle, but circular walls are more expensive than straight walls. As mentioned above, the least outside wall in relation to area in a rectangular building is in the square, but the need for windows and for insulation of noisy areas may mean that this is not practicable. Often several small buildings may call for less outside wall area than the same square footage in a single, very irregular building.

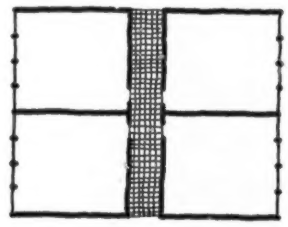
TRAFFIC Corridors cost money and contribute little to the school program unless they are used for other purposes as well. Some plans are more frugal of corridor space than others. Some schools in temperate climates have almost entirely eliminated corridors. Note that single loaded corridors require almost twice as much corridor per classroom as double loaded corridors.

Economy can also be achieved in typical schools with rectilinear classrooms of say 28 by 32 feet by placing the short end of the classroom parallel to the hall. For each two classrooms 8 linear feet of hallway are saved (probably 64 square feet, or $1,024 at $16 per square foot).

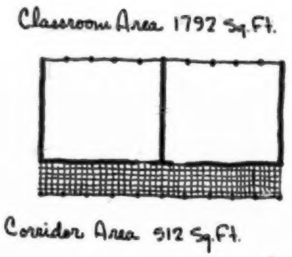
Some cluster plans involve irregularly shaped, and consequently more expensive, exterior walls, but are frugal with corridor space and often accumulate it in one area where it may be used for various educational purposes.

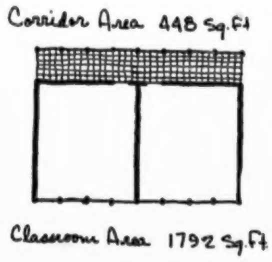


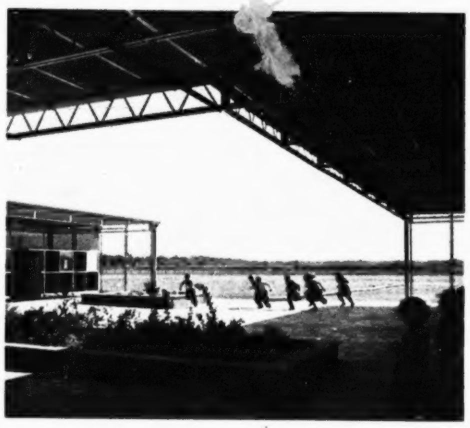
Single Loaded Corridor



Double Loaded Corridor

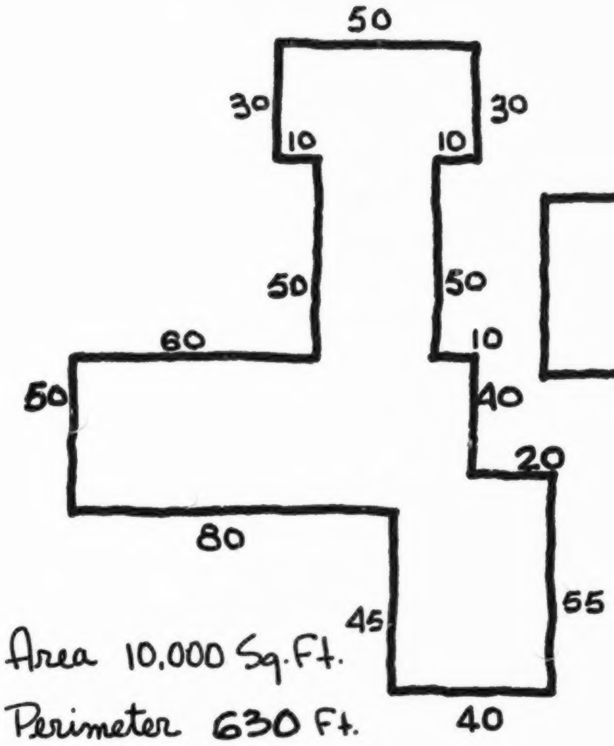






Outdoor corridors can save space and dollars.

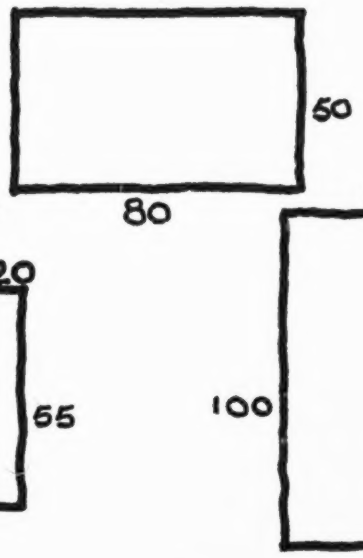
Detailing The simplicity of the process of putting the materials and mechanical components of the building together has a big effect


50
30
30
10
10
50
50
60
10
50
40
20
80
55
45
40

Area 10,000 Sq. Ft.

Perimeter 630 Ft.

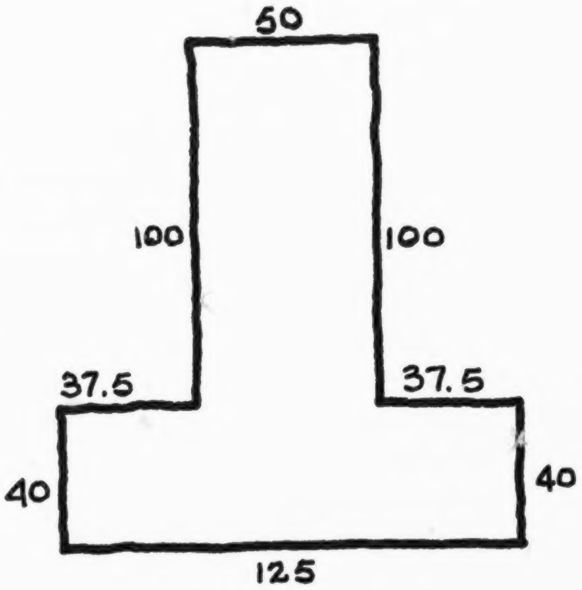
Ratio of $\frac{\text{Area}}{\text{Perimeter}}$ $\frac{15.9}{1}$



Area 10,000 Sq. Ft.

Perimeter 580 Ft.

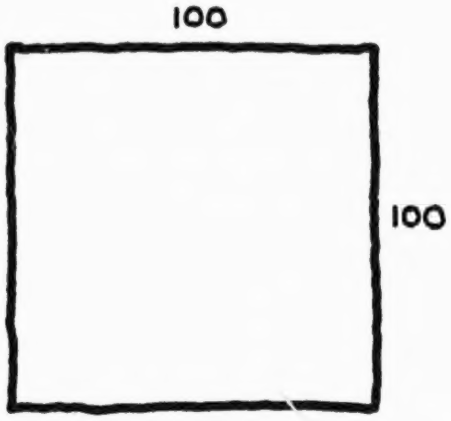
Ratio of $\frac{\text{Area}}{\text{Perimeter}}$ $\frac{17.2}{1}$


50
100
100
37.5
37.5
40
40
125

Area 10,000 Sq. Ft.

Perimeter 530 Ft

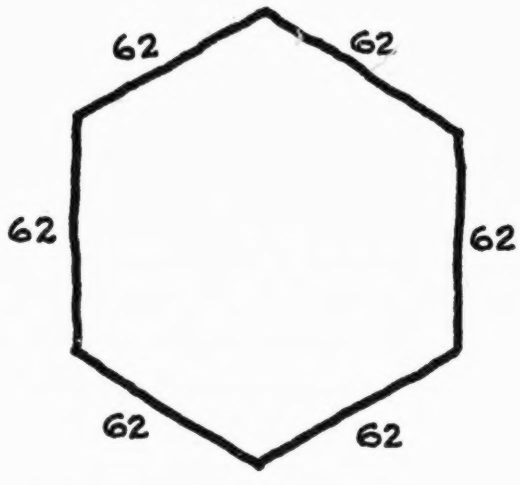
Ratio of $\frac{\text{Area}}{\text{Perimeter}}$ $\frac{18.8}{1}$



Area 10,000 Sq. Ft.

Perimeter 400 Ft

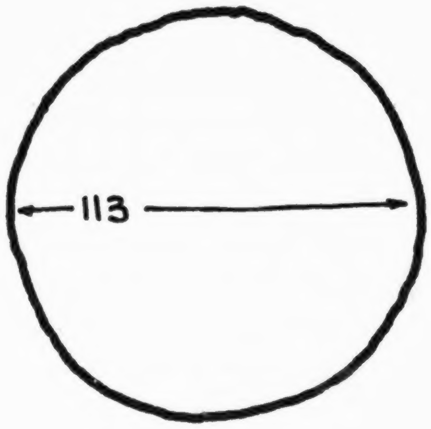
Ratio of $\frac{\text{Area}}{\text{Perimeter}}$ $\frac{25.0}{1}$


62
62
62
62
62
62

Area 10,000 Sq. Ft.

Perimeter 372 Ft.

Ratio of $\frac{\text{Area}}{\text{Perimeter}}$ $\frac{26.8}{1}$



Area 10,000 Sq. Ft.

Perimeter 355

Ratio of $\frac{\text{Area}}{\text{Perimeter}}$ $\frac{28.2}{1}$

on the cost. The men who actually put the building together are always concerned with nailing one piece of wood to the next, laying brick on brick, or fitting the sheet metal conduit into place in *accordance with the blueprints.* They live and work with what architects—some respectfully and some contemptuously—call "a matter of detailing." If the detail is simple and the blueprint is adequate, accurate, and understandable, they can do it quickly and well; if the detail is intricate, or if the blueprint specifications are inaccurate or confusing, payrolls are wasted. Furthermore, it is generally recognized that the *quality of detailing,* in terms of simplicity and grasp of the process of building as viewed from the perspective of the contractors and building trades, has a significant bearing on the bid prices which contractors are willing to make.

Unlike most other easy generalizations, the statement "the simpler the detail, the less costly the structure" is true. Simplicity in detail, far from involving sacrifice in quality, will enhance it.

It is necessary, however, to distinguish between simplicity of *detailing* and simplicity of *over-all design.* A very intricate over-all design such as a geodesic dome or a space frame which is put together by repeating the same simple detail over and over again is economical. On the other hand, some of the simplest looking straight window walls may have required elaborate detailing.

Acoustics Acoustical standards are only beginning to be recognized. The still widespread acceptance of acoustically substandard spaces, particularly in schools, is simply a result of teachers and administrators not appreciating what good acoustics are. Unfortunately some people think of acoustics as a ceiling with little holes in it.

The two most basic school problems are reverberation control within rooms by sound absorption and the reduction of sound transmission from room to room.

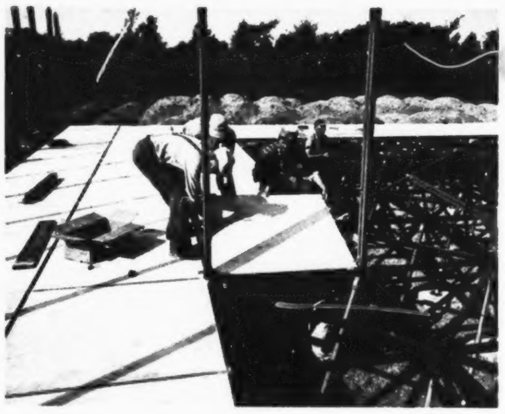
Acoustic standards have delicate limits up and down. One can say of thermal insulation that the more of it the better, though some be wasted. But this is not so of acoustic absorption. An acoustically dead room is nearly as bad for some purposes as a noisy one. Requirements vary widely according to room use. Accordingly, ideally correct acoustical design treats each room as a one-purpose space, contrary to the principle of flexibility.

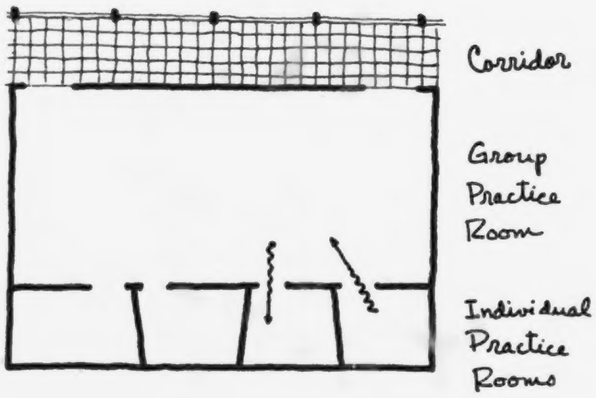
Isolation of sound requires either physical isolation or barriers. To stop sound a wall must have mass and the less porous, the fewer holes—doors, cracks, etc.—the better. The problem of speech privacy between rooms is lessened by use of masking noise (known in the trade as acoustic perfume) from unit ventilators, air conditioning, and other regular noise makers. The quieter a classroom is, the more annoying the sound next door—as for example the proverbial dripping faucet at night when you are trying to sleep.

Isolation of sounds from shop machinery is more difficult. First, try to quiet the machines. Second, try to isolate the shop physically. Music also poses special problems. Watch out for music rooms so near the auditorium that both cannot be used at once.

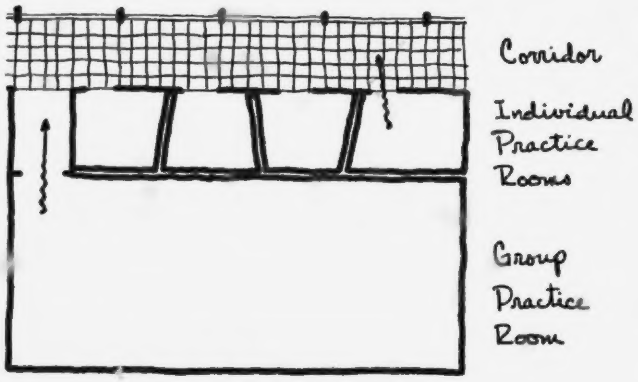
Other areas of special concern are music practice rooms, listening rooms, language laboratories, and gyms. All should receive acoustic planning. Either specially planned walls and doors, or physical isolation from each other and from quiet areas is needed to keep them from being a problem.

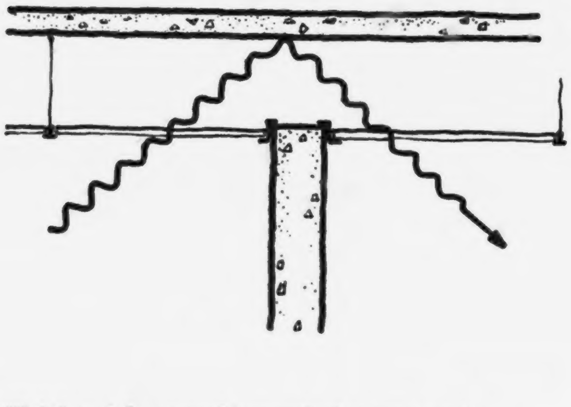
Repetitive elements can save money and construction time by eliminating the custom fitting of each joint.





Music areas should be planned so the use of one room will not interfere with the neighboring practice rooms or vice versa.





Watch out for sound transmission over partitions when hung ceilings are used.

Hung ceilings are a source of trouble if regular acoustic tile is used—sound goes through the ceiling and bounces down into the next room, unless the wall goes up to the roof deck or the bottom of the floor above in a multi-story building. If the walls don't go past the hung ceiling, use acoustic tile with a backing to stop sound. The tiles ordinarily absorb sound but don't stop it—just as a sponge absorbs water but would hardly make an ideal raincoat.

Among the means of reverberation control within the classroom are:

▪ Acoustic tiles fastened to all or part of the ceiling and/or upper reaches of the walls, heavy drapes, rugs, and students, all of which (and of whom) absorb sound. It has been found that two or three rows of tiles on the wall and the same amount on the ceiling along the line where walls and ceilings meet, are as effective as—or more effective than—tiles over the entire ceiling in typical classrooms. Often tiles on half the ceiling are enough. An excessively dead (acoustically absorptive) classroom will put a strain on the teacher who must make himself heard and the children who must hear and be heard. But acoustic problems, like other school building problems, must be approached room by room, school by school.

▪ Acoustic tiles may be of perforated or fissured vegetable fiber or of many other materials. The greater the thickness, the more effective they are, although the differences in effectiveness are basically insignificant. Normally they range from 60 per cent to 80 per cent absorptive.

▪ Vegetable fiber tiles are combustible even when flameproofed, and they should only be applied to a solid fire resistant surface such as plaster or plasterboard not laid in a grid of open framework (suspended ceiling).

▪ Mineral fiber tiles should be used in damp locations (kitchens, locker rooms, certain shops) where fire resistance is important.

▪ Perforated metal (aluminum or painted steel) or perforated asbestos sheets, all backed by an absorbent blanket of Fiberglass, are fire resistant and will stand dampness; for large unbroken ceiling areas where the economy of large units becomes effective, they are almost competitive in price with the vegetable fiber tiles. They are especially adapted to use in kitchens, corridors, and lobbies.

The simplest and cheapest form of acoustical insulation, one perfectly acceptable for gymnasiums and shops, is the use of a type of roof deck, the exposed underside of which has acoustical properties. These may be either lightweight prefabricated panels or gypsum or lightweight concrete poured over a permanent form of acoustical fiberboard. For furred ceilings, acoustic plaster is also available, but it is seldom competitive in price with other forms of sound absorption. It loses its acoustical value after several coats of paint. Another tool of the acoustical engineer is the design of the shape of the ceiling (and even of the walls)—the use of baffles, directional breaks, and reflecting, sometimes floating, surfaces used in the same manner in which the lighting engineer uses wall and ceiling surfaces as light reflectors.

The special acoustical problems of music rooms, auditoriums, and large group teaching rooms may call for an acoustical consultant.

Sound systems also call for special consultants. A cheap sound system is not only a poor buy initially in terms of performance, but is unlikely to stand up as well as a first rate system.

Flexibility Flexibility means a number of things to architects and school administrators. But here are some of the kinds of flexibility which you will do well to consider.

Multiple use of space, as in the unfortunately named cafetorium which serves as both a cafeteria and auditorium, is one approach to flexibility. This particular combination involves a compromise in acoustics, floor slope, room shape, and other factors, but it can work and save money. It involves much furniture moving (which costs money). Other combinations such as auditorium-gymnasium or gymnasium-cafeteria are possible but usually less successful. An auditorium divisible into three large group teaching areas is now being built in Boulder City, Nevada, with EFL assistance. It promises substantial economies. In a large school it can save five classrooms. Because of the compatible multiple uses, few compromises are called for. It combines the kind of flexibility mentioned above with flexibility at will.

Flexibility through movable walls is often used in offices. It acknowledges the fact that the building will never be finished—that it must change as the process it contains changes. The Hillsdale and Mills High Schools in San Mateo, California, designed by John Lyon Reid, are almost completely flexible. At the Hillsdale School they have recently moved a number of walls to accommodate a new program in business education. With this flexibility a crew of maintenance men can remake whole areas of the school over the week end.

Flexibility through electronics, i.e., television, makes it possible to communicate with a large group in more than one room at once. This is another approach to getting the walls out of the way of the program.

Flexibility at will is the ability to pull a wall out of the way and join two spaces or divide one at once, that is, within a minute. It provides for higher utilization of space and a more adaptable school.

There is not, as of this writing, an economical, operable wall which can be removed or replaced by a teacher and which will provide real speech privacy between two areas. However, several manufacturers have been working seriously on this problem and will be field testing such walls during 1960. Partitions of this kind are not far off and they offer substantial possible economies through multiple space use. EFL is exploring a neoprene sealed, woven wall of fabric and lead which has tested well in the laboratory.

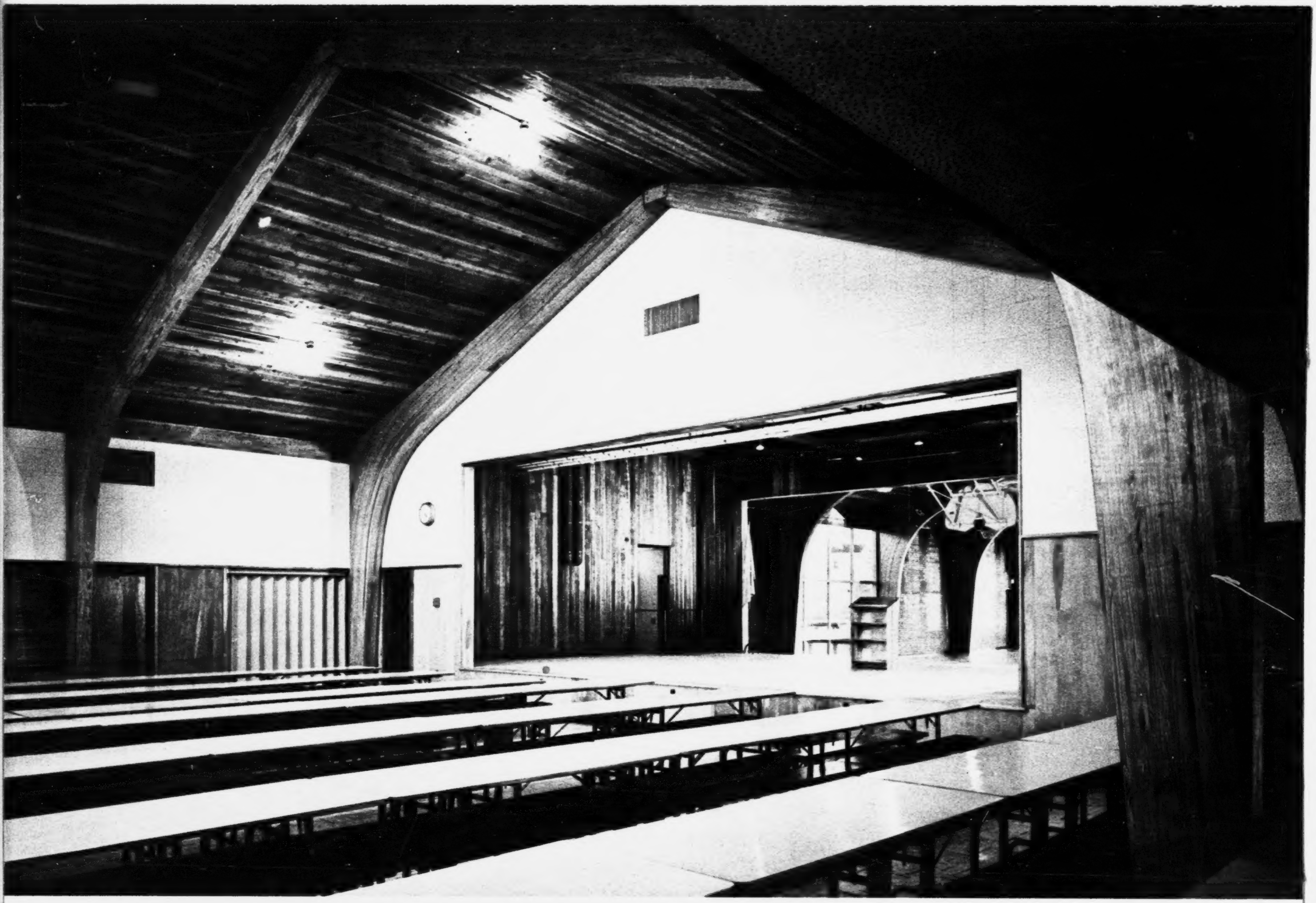
The economics of flexibility are in space saved through higher use of space built. This means higher per square foot cost in almost all cases but fewer square feet for the same facilities.

The danger of flexibility—as in most things—lies in its misuse, in the assumption that activities requiring incompatible facilities can be carried out in the same space. The gymnasium-cafeteria is a good example—merging the smell of sweat and peanut butter and involving daily furniture moving, gymnasium falls from food spilling, and a daily program interruption.

But small classrooms which can be opened into larger classrooms, auditoriums divisible into large classrooms, classrooms divisible into seminar rooms, and other combinations are possible, do not involve excessive compromises, and hold forth the possibility of real economies.

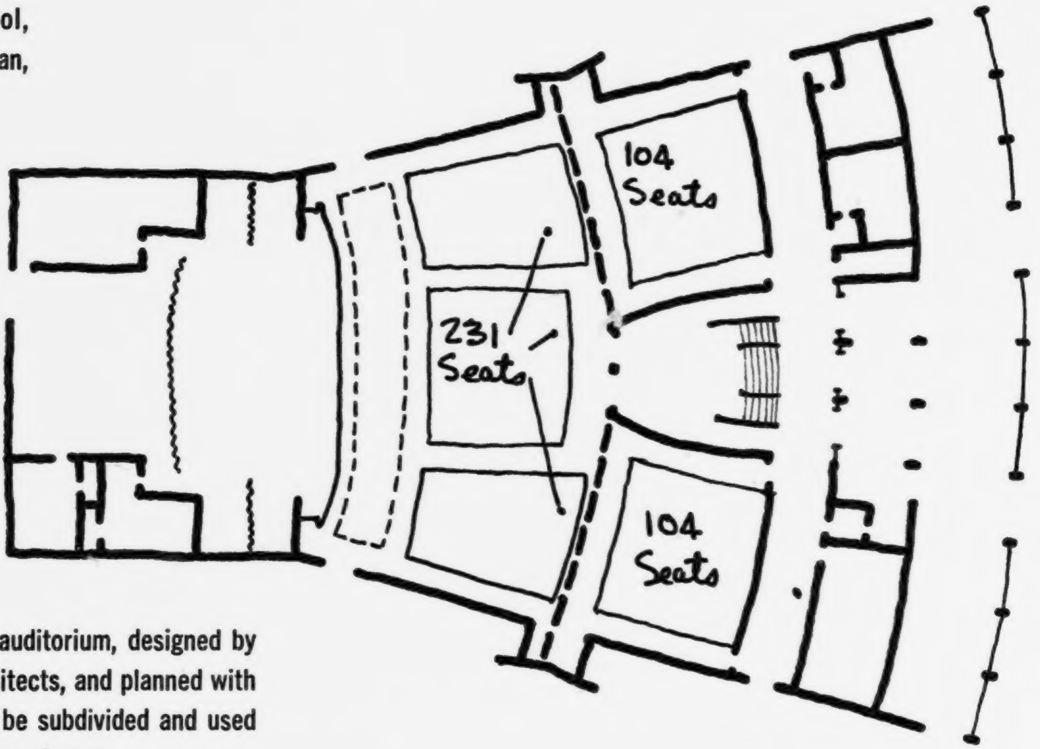
Fire Protection Two separate questions are involved: they are *safety of occupants* (which naturally should outrank all other consider-

Operable walls are one approach to flexibility.



Other approaches involve multiple use of space as in the combination cafeteria-auditorium above. Westminster School, Westerly, Rhode Island. Alonzo J. Harriman, Inc., architect.

Flexibility



The Boulder City auditorium, designed by Zick and Sharp, architects, and planned with EFL assistance, can be subdivided and used for instruction of large classes.

ations), and *safety of investment* (which can be considered on a dollars and cents basis and with which compromises can be made).

Safety of occupants means adequate exits and stairs, a degree of fire resistance in the building to allow orderly evacuation in case of fire (this degree to be set considerably higher for multi-story building), fire alarm systems, and possibly fire detection and/or sprinkler systems. Many of these features are required by local building laws, though always in a minimal way. Compliance with these regulations should never be allowed to be the clinching argument for having done enough to insure fire safety. Every aspect of the situation should be examined on its merit. If the law allows the distribution of the exit load among all stairs, but it seems probable that in case of fire one stairway will carry most of the load, then this stairway should be made wide enough for the total load. There can never be too many exits or too straight a path of exit. Consider that in an average year 18 persons lose their lives in school fires.

Laws and ordinances are, as a rule, concerned only with the safety of occupants, not with the considerations which follow.

Safety of investment, on the other hand, can be accurately calculated on the basis of literal adherence to the rules by which the insurance companies rate buildings in terms of fire resistance of all components of the structure, ranging from zero (wood frame or entirely unprotected metal building) to four-hour resistance (never used for schoolhouse construction). These rules vary from region to region and some of them do not make much sense, but they are the ones by which we must select the materials and construction which determine the fire rating of the building.

The entire building is rated according to the rating of its weakest part. Money spent on making any part or component of the structure fit for a higher rating than the rest of components is wasted money from the investor's point of view. The rate differential reflected in the premiums seldom pays for upgrading the entire structure even for a long period. There may be exceptions to this rule if the town pays premiums on a package of buildings which would be pulled down by the addition of a new one rated substantially lower than all the others.

The insurance agent should be consulted before a final decision is made concerning the rating for which the building is to be designed. He should be asked for a preliminary rating; no architect, let alone a layman, can divine the mysterious ways in which the insurance rate-setter's mind arrives at the announced result. Check the completed design again with the insurance agent before the drawings go out for bids. Ask for and take his advice for making adjustments in the design, for obtaining better ratings often without additional cost.

On Parts and Wholes

Designing a building is more than collecting materials and spaces. Good design is more a system than a collection. Discussing the elements of the building tends to make one think in terms of the pieces. But always remember that a well-designed school is a system, the whole is greater than the parts, and the parts are basically interconnected. In short, it is what is called in psychology a *gestalt*.

Designing involves choosing. The order and logic of the choices

excludes further consideration of other factors and restricts subsequent choices. Each choice is based on many criteria. Will it work? Is it suitable to the site? Is it suitable to the neighborhood? Is it reasonable in terms of the arrangement previously made? How will it affect choices still to be made? Will it fit the budget? Is it logical from the point of view of structural engineering? Will it add too much to the cost of heating? Each choice once made implies the rejection of all other possibilities. Each choice once made limits the freedom of all further choices still to be made. The arrangement of rooms and their grouping will have determined the disposition of wings. The shape and size of the rooms limits the choice of column spacing to a few possibilities. Once the column spacings are set we are no longer free to select just any type of windows. They must fit between the columns. And over all these decisions are considerations of:

- Suitability to function (program).
- First cost.
- Maintenance.
- Permanence.
- Replacement cost.
- Appearance.
- Acceptability to the community.

THE ELEMENTS

The Shell

The factors involved in selecting the shell of the school, including the structure and outside skin (roof, walls, and windows) have been outlined so well in Walter McQuade's *Schoolhouse* that we have reprinted his charts on "Structural Framing," "Roof Deck and Roof Construction," and "Exterior Walls."

It is difficult to make a general statement as to what system and which materials will be most economical. Local labor, seasonal conditions, delivery cost of materials, and the time available for construction will all influence these choices.

Windows There is a growing tendency on the part of designers to use large panes of glass both for fixed and operable sashes. This is costly. It may necessitate the use of expensive plate glass instead of the cheaper double strength glass. A large operating sash is more difficult to open and close and requires more maintenance. Special glass, such as tempered glass, heat absorptive glass, glare shielding glass, double glass, or glass block, is seldom justified economically. But it may be justified in terms of the plan and program of a particular school. The degree of contribution to control of the thermal and visual environment must be the determining factor. Difficulty of replacement as well as initial cost needs to be taken into account in any use of large panes or special glass.

Any putty within reach of up to third graders must be replaced every six months. (Putty seems to lose its fascination by the time the fourth grade is reached.) Glass stops (metal beads) for the lower panes if they are within children's reach pay for themselves in a couple of years.

The charts which follow are from **Schoolhouse,** produced by Aluminum Company of America, Eggers and Higgins, Architects, and Walter McQuade; Simon and Schuster, New York, 1958. They indicate a few typical cards in the hands of the school builder—some of the more commonly used familiar assemblies of structural framing, exterior walls, roofs, windows, lighting, with comments on their qualities drawn from the professional experience of the building consultants to the editor of **Schoolhouse,** and with comparative cost indications noted in one locality in one period by the technicians of the George A. Fuller Company.

Not all these comments apply precisely nationwide, of course, nor do all the bar chart cost comparisons; labor and materials vary considerably from one town to the next. But the comparative costs indicated in these charts, both first cost and twenty years cost (including maintenance, insurance, and, when necessary, replacement) can be checked out locally by your architect and builder, who will also have comments on special advantages and disadvantages of these techniques for your own use. Throughout the comparisons, our classroom is sized at 28 feet by 32 feet, with a ten foot ceiling, and the job size assumed is the construction of an eight-classroom wing. Costs are comparative within each chart.

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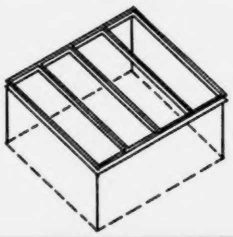
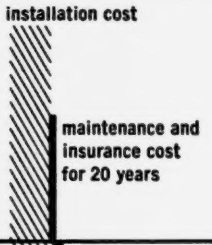
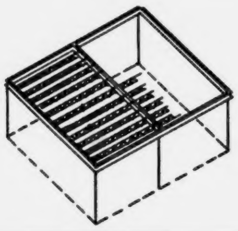
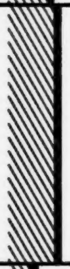
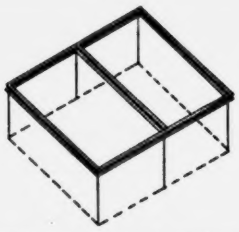
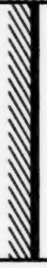
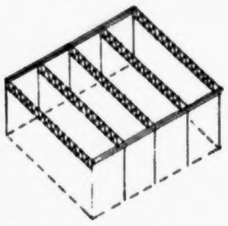
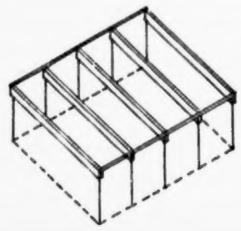
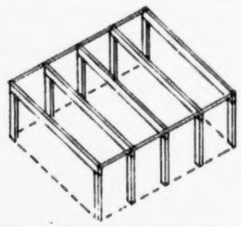
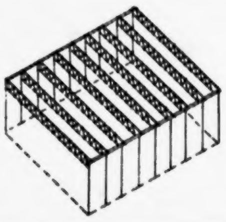
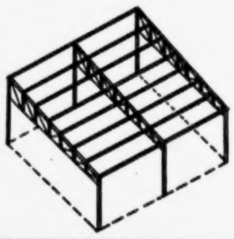
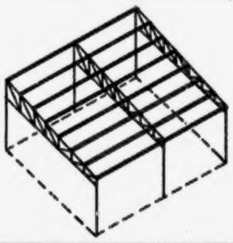
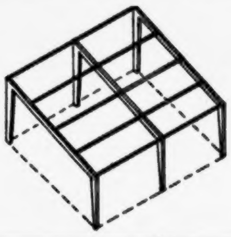
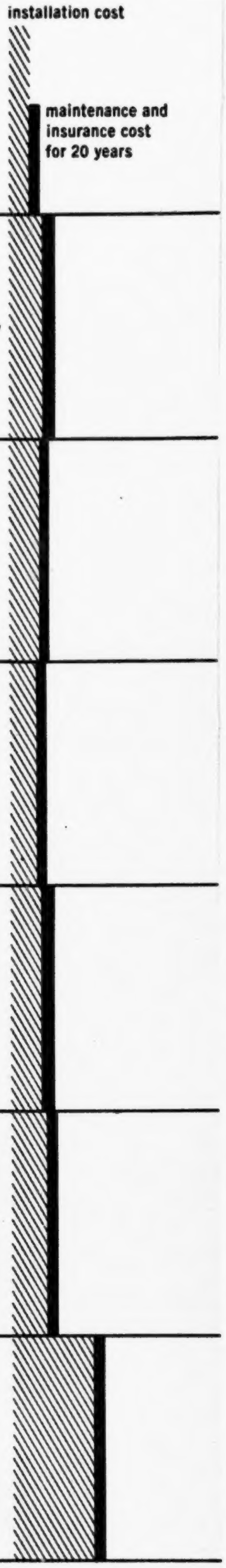
STRUCTURAL FRAMING

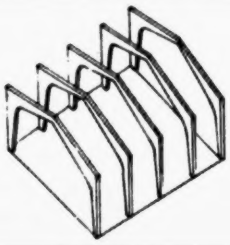
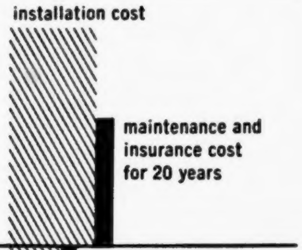
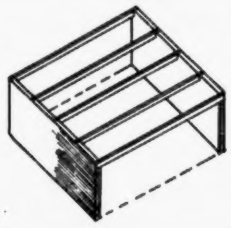
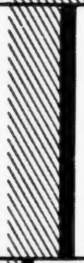
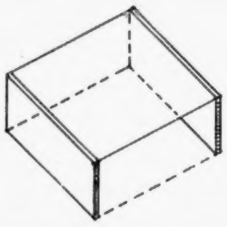
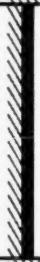
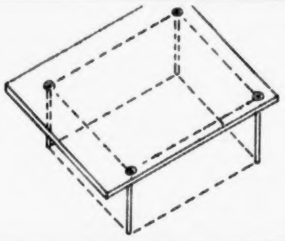
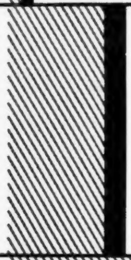
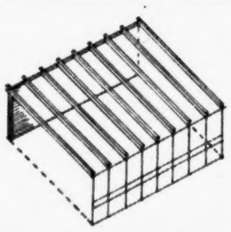
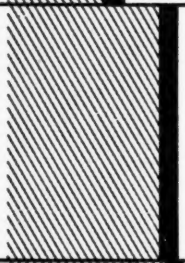
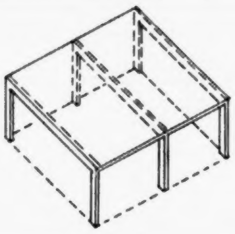
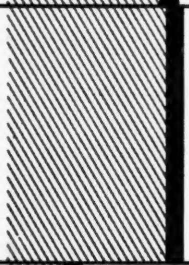
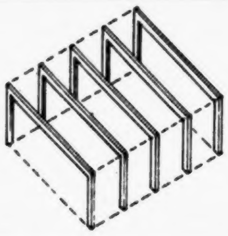
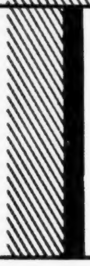
FRAMING SYSTEM	NECESSARY DECKSPAN WIDTH	FIRE RESISTANCE	BUILDING SPEED	REMARKS	COST COMPARISON
 Vertical support: lally (steel pipe) columns, 4 inches in diameter, set at corners; Roof framing: rolled steel beams (size, 21 WF 68) spanning 32 feet; cross members of rolled steel beams (size, 12 WF 27) spanning 28 feet, spaced 8 feet apart	8 feet	Incombustible, but fire-rated under one hour without applied fire-proofing	Fast; can be riveted, bolted or welded	Long spans, few footings; no walls bear weight (they can easily be rearranged without affecting the structure)	
 Vertical support: 3½ inch lally columns set at corners and midway in longer wall; Roof framing: rolled steel beams (size, 16 WF 36) spanning 28 feet; cross members of 10 inch bar joists (light, open web steel beams) spaced 2 feet apart; steel beams (8 WF 17) over columns	2 feet	Incombustible, but fire-rated under one hour	Fast; bar joists can be handled without elaborate hoists	Column-free and flexible; if framing is left exposed, dust is sometimes a problem, and the ceiling cannot be used well for indirect lighting	
 Vertical support: 3½ inch lally columns set at corners and midway in longer wall; Roof framing: rolled steel beams (size, 16 WF 36) spanning 28 feet, spaced 16 feet apart; steel beams (8 WF 17) over columns	16 feet	Incombustible, but fire-rated under one hour	Very fast; one step is omitted when roof deck takes over the structural task	Has advantages of relatively few columns and no weight-bearing walls; also has clear ceiling with only one cross beam (but cost of wide span decking must be taken into account)	

STRUCTURAL FRAMING continued

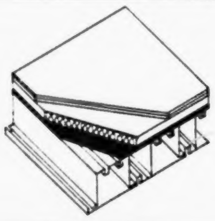
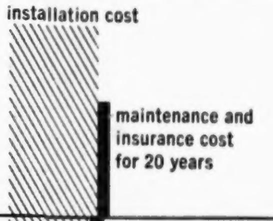
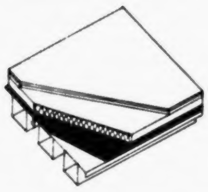
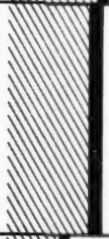
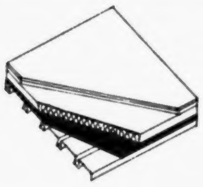
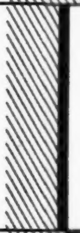
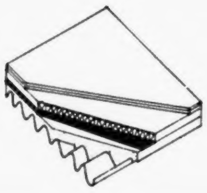
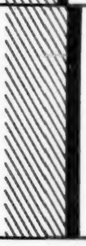
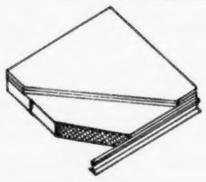
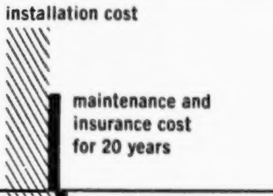
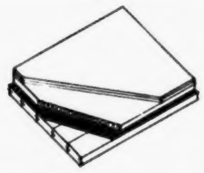
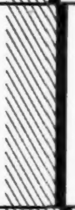
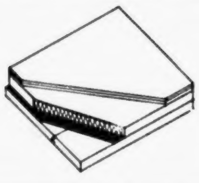
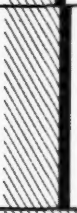
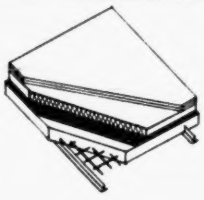
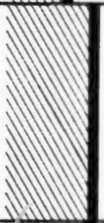
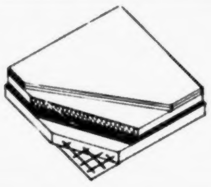
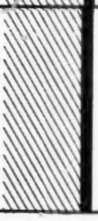
	FRAMING SYSTEM	NECESSARY DECKSPAN WIDTH	FIRE RESISTANCE	BUILDING SPEED	REMARKS
	Vertical support: 3½ inch lally columns set 8 feet apart on long side; Roof framing: 18 inch bar joists, spanning 28 feet, spaced 8 feet apart; light steel beams (8 by 13) over columns	8 feet	Incombustible, but fire-rated under one hour	Fast	Fairly clear ceiling; there are numerous vertical columns, yet they don't impose any serious limitations in flexibility; the end walls can still be removed structurally
	Vertical support: 3½ inch lally columns set 8 feet apart on long side; Roof framing: steel angles (size, 4 by 6 inches) over columns, with cross members of laminated wood beams (size, 5¼ by 18 inches) spanning 28 feet	8 feet	Combustible; many codes frown on timber construction, but it does retain strength even when charred	In theory fast, but in practice usually only fair; two separate building trades are involved	Fairly clear ceiling; many people like appearance of exposed laminated wood beams, especially if stained and waxed instead of painted
	Vertical support: 4 by 7 inch wood columns set 8 feet apart on long side; Roof framing: 4 by 6 inch steel angles over columns, with cross members of laminated wood beams (size, 5¼ by 18 inches) spanning 28 feet	8 feet	Combustible, but see above	Fair	Same advantages as above, but wood columns take up somewhat more space
	Vertical support: 4 inch nailable steel studs (slim steel columns) spaced 4 feet apart on long side; Roof framing: 18 inch bar joists, spanning 28 feet, spaced 4 feet apart; 3 by 4 inch steel angles over columns	4 feet	Incombustible, but fire-rated under one hour	Fast	Light, easy construction, allows cost-saving in roof decking, but tight spacing of the studs in the walls limits flexibility
	Vertical support: 3 by 10 inch wood columns set at corners and midway in longer wall; Roof framing: wood trusses, 36 inches high at one end, sloping up to 48 inches at other, spanning 28 feet; cross members of 4 by 12 inch wood, spaced 4 feet apart	4 feet	Combustible	Fair	A simple structure with few columns, allowing substantial flexibility; usually, however, a suspended ceiling must be added below the trusses
	Vertical support: 3½ inch lally columns set at corners and midway in longer wall; Roof framing: steel trusses, 36 inches high at one end, sloping up to 48 inches at other, spanning 28 feet; cross members of 4 by 12 inch wood, spaced 4 feet apart	4 feet	Combustible	Fair	Remarks above apply here also
	Vertical and roof framing are combined: the rigid steel members (size, 18 WF column and girder) span 28 feet, spaced 16 feet apart; cross members are steel beams (size, 10 WF 21) spanning 16 feet, spaced 7 feet apart	7 feet	Incombustible, but fire-rated under one hour	Very fast, with proper hoisting equipment	A spare, trim way to build with few elements

COST COMPARISON

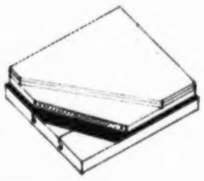
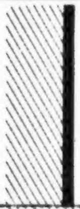
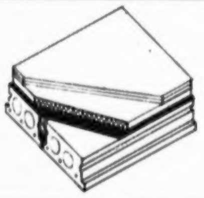
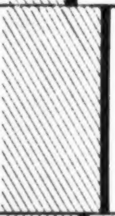
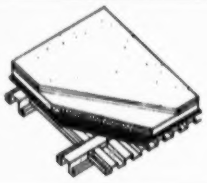
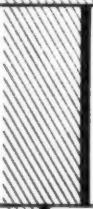
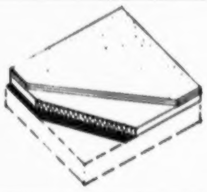
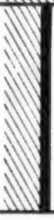


FRAMING SYSTEM		NECESSARY DECKSPAN WIDTH	FIRE RESISTANCE	BUILDING SPEED	REMARKS	COST COMPARISON
	Vertical and roof framing are combined: the laminated wood members (size varies from 5⅛ by 5 inches to 5⅛ by 40 inches) span 28 feet, spaced 8 feet apart; roof slopes up 3 inches per foot toward peak at center of span	8 feet	Combustible	Very fast	Numerous columns, but placed on exterior walls where they will not interfere with the rearranging of interior partitions	
	Vertical support: weight-bearing walls of solid concrete (which become the partition walls between the classrooms); Roof framing: laminated wood beams (7¼ by 18 inches) spanning 32 feet, spaced 7 feet apart	7 feet	Combustible	Walls slow, roof fast	A simple, solid way to build, but with no flexibility whatsoever (the partition walls are permanent); Also, running the beams the long way throws shadows on the ceiling, reducing its effectiveness as a reflector of daylight from the windows	
	Vertical support: solid 8 inch concrete weight-bearing walls (the partition walls between the classrooms); Roof framing: long span steel or concrete roof deck	None needed	Depends on deck selected (the walls have a 4 hour fire-rating)	Walls slow, roof fast	The simplest way to build and apparently the cheapest; cost includes partition walls, but the cost of long span roof decking will probably eat up the money saved using this framing method; inflexible	
	Vertical support: 8 inch lally columns; Roof framing: reinforced concrete slab, spanning 31 feet by 27 feet, poured on floor slab and jacked up columns into place	32 feet	Incombustible, with 4 hour fire-rating	With proper scheduling, fair	A very flexible way to build, with few columns and a clear, clean ceiling for reflecting light; heavy, it sometimes calls for expensive foundations; cost figure, however, includes roof decking	
	Vertical support: 4 foot wide, weight-bearing, prefabricated aluminum panels (cross bracing provided by partition walls); Roof framing: steel beams (size, 12 WF 25) spanning 28 feet, spaced 4 feet apart	4 feet	Incombustible, but fire-rated under one hour	Very fast	Very flexible	
	Vertical support: 14 by 20 inch reinforced concrete columns, poured in place, set at corners and midway in longer wall; Roof framing: 14 by 20 inch reinforced concrete beams, poured in place under a 6½ inch reinforced concrete slab	None	Incombustible, with a 4 hour fire-rating	Slow, needs framework and setting time	Heavy construction but few columns; fairly flexible for rearranging partitions; maintenance low; cost includes usual roof deck	
	Vertical and roof framing are combined: the prefabricated, prestressed concrete frames span 28 feet, spaced 8 feet apart; columns are 10 by 12 inches, beams 5 by 18 inches	8 feet	Incombustible, with a 4 hour fire-rating	Fast, if heavy equipment is used	Heavy construction but still quite flexible, columns do not interfere with the moving of interior partitions	

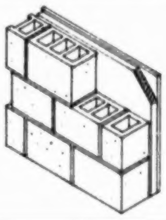
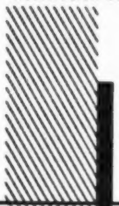
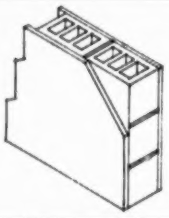
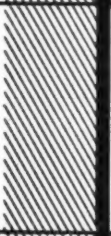
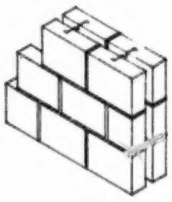
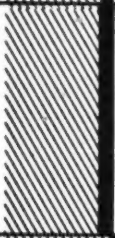
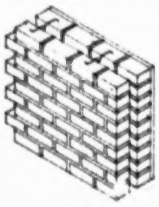
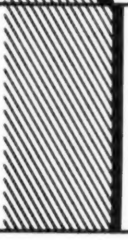
ROOFDECK AND ROOF CONSTRUCTION

DRAWING AND DESCRIPTION	DECK SPAN	FIRE-RATING	INSULATING QUALITY	REMARKS	COST COMPARISON
 5 ply built-up roofing 2 inch rigid insulation with vapor barrier 7½ inch steel decking, painted on ceiling side	28 feet	Incombustible, with a fire-rating of less than one hour	Good; U value— .15	Very easily erected; poor acoustically unless underside receives at least ½ inch acoustical treatment; wiring for lighting fixtures can be run through cavities in deck	
 5 ply built-up roofing 2 inch rigid insulation with vapor barrier 4½ inch steel deck, painted on ceiling side	16 feet	Incombustible, with a fire-rating of less than one hour	Good; U value— .15	Very easily erected; poor acoustically unless ceiling receives at least ½ inch acoustical treatment or deck is perforated	
 5 ply built-up roofing 2 inch rigid insulation with vapor barrier 1½ inch ribbed steel deck, painted on ceiling side	8 feet	Incombustible, with a fire-rating of less than one hour	Good; U value— .15	Very easily erected; poor acoustically unless ceiling receives at least ½ inch acoustical treatment	
 5 ply built-up roofing 2 inch rigid insulation with vapor barrier light weight, reinforced concrete fill on corrugated steel deck, painted on ceiling side	8 feet	Incombustible, with a fire-rating of less than one hour	Good; U value— .13	Speed of erection is fair; concrete fill process will slow down completion; underside can be left exposed, but this is not general practice unless it is acoustically treated	
 5 ply built-up roofing 2⅞ inch wood fiber-and-concrete composition board roof deck on steel subpurlin supports	8 feet	Incombustible, with a fire-rating of less than one hour	Good; U value— .16	Very easily constructed; underside can be left exposed or painted with joints concealed by the supporting subpurlins; Very good acoustically	
 5 ply built-up roofing 2 inch rigid insulation with vapor barrier 2 by 6 inch tongue-and-groove wood deck, stained, painted or waxed on ceiling side	4 feet	Combustible	Very good; U value— .12	Easily erected; deck underside is frequently left exposed, but further acoustical treatment is recommended	
 5 ply built-up roofing 2 inch rigid insulation with vapor barrier 2 inch gypsum plank with metal edging, painted on ceiling side	4 feet	Incombustible, with a fire-rating of less than one hour	Good; U value— .13	Easily erected; deck can be left exposed, but further acoustical treatment is recommended	
 5 ply built-up roofing 2 inch rigid insulation with vapor barrier gypsum deck (poured in place) on acoustical form-board with reinforcing steel wire and steel subpurlin supports	8 feet	Incombustible, with a fire-rating of one hour	Good; U value— .15	Fairly easy construction (the poured-in-place deck will delay completion of roof); deck can be left exposed as ceiling; good acoustically	
 5 ply built-up roofing 2 inch rigid insulation with vapor barrier 2 inch concrete slab poured on galvanized steel wire with waterproofed backing attached	2 feet	Incombustible, with a fire-rating of one hour	Good; U value— .15	Erection speed is fair, the poured deck must set before being roofed; needs a hung ceiling for finish	

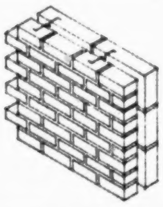
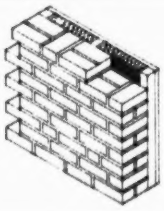
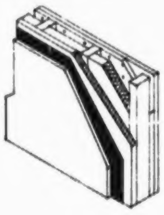
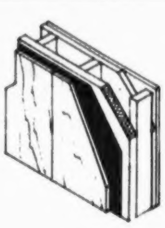
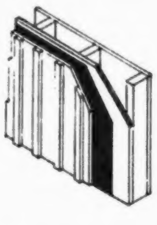
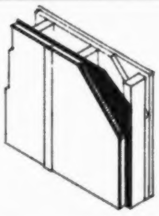
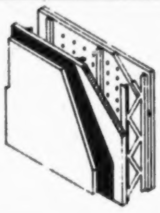
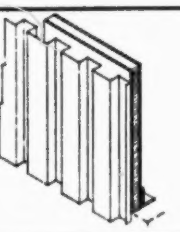
ROOFDECK AND ROOF CONSTRUCTION continued

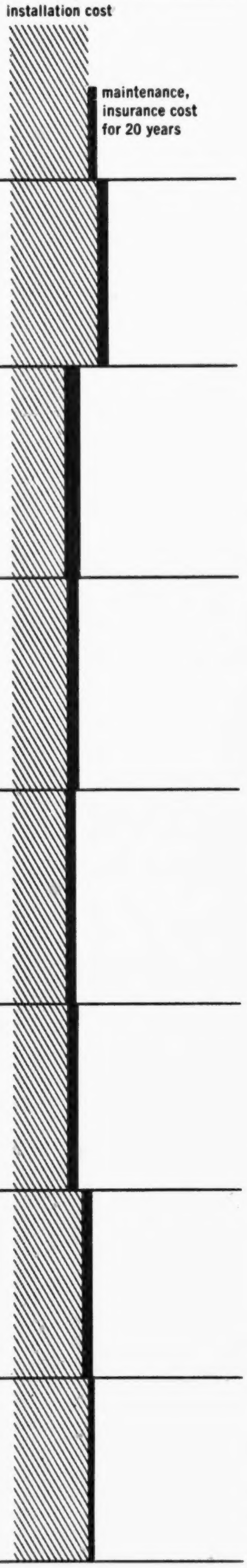
DRAWING AND DESCRIPTION		DECK SPAN	FIRE-RATING	INSULATING QUALITY	REMARKS	COST COMPARISON
	5 ply built-up roofing 2 inch rigid insulation with vapor barrier 2 ¾ inch nailable concrete plank with tongue-and-grooved joints, painted	8 feet	Incombustible, with a fire-rating of one hour	Good, U value— .15	Erection time is good; can be drilled and sawed; ceiling can be left exposed, but some further acoustical treatment is recommended	
	5 ply built-up roofing 2 inch rigid insulation with vapor barrier 8 inch long-span, hollow core, concrete plank deck, painted	28 feet	Incombustible, with a fire-rating of two hours	Very good; U value— .10	Good erection time; deck can be left exposed, but further acoustical treatment is necessary	
	5 ply built-up roofing 2 inch rigid insulation with vapor barrier, supported on aluminum roofdeck steel subpurlin supports, spaced 2 feet apart	8 feet	Incombustible, with a fire-rating of less than one hour	Good; U value— .15	Erection speed is good; deck can be left exposed, but needs acoustical treatment	
	5 ply built-up roofing 2 inch rigid insulation with vapor barrier 5½ inch concrete slab, poured in place	16 feet	Incombustible, with a fire-rating of four hours	Good; U value— .13	Slow erection time; slab needs setting time; the under side of slab is frequently left exposed (painted), but further acoustical treatment is required	 (cost does not include slab)

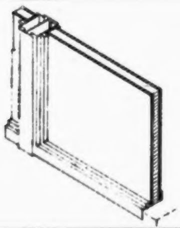
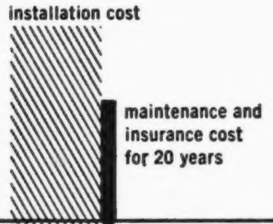
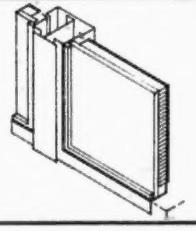
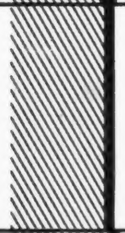
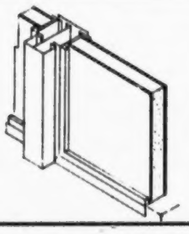
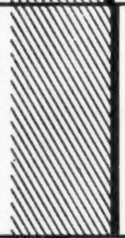
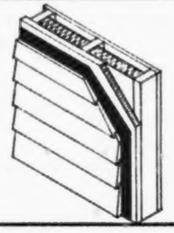
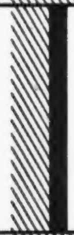
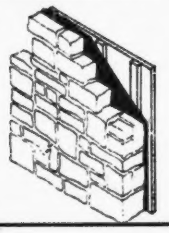
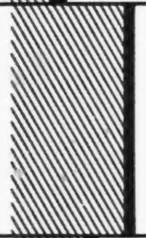
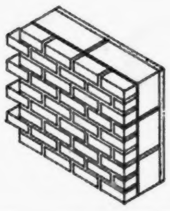
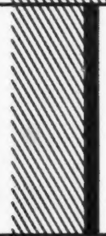
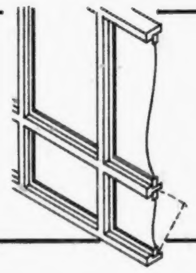
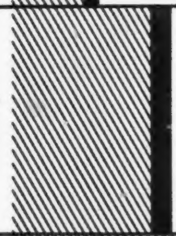
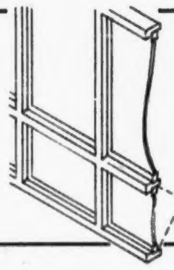
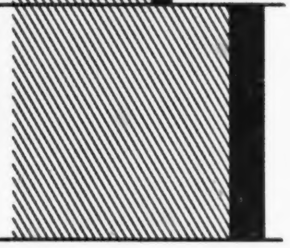
EXTERIOR WALL CONSTRUCTION

DRAWING AND DESCRIPTION		FIRE-RATING	INSULATING QUALITY	MAINTENANCE	REMARKS	COST COMPARISON
8 inch concrete block, water-repellent paint on exterior 2 inch foam insulation applied with cement mortar to concrete block ¾ inch layer of plaster, painted thickness, 11 inches; weight, 50 lbs. psf		Incombustible, with a fire-rating of three hours	Very good U value—.14	Fair, soils somewhat	Weightbearing; expensive for framing windows; very good condensation control	installation cost  maintenance and insurance cost for 20 years
	8 inch concrete block, 1 inch cement stucco on exterior ¾ inch layer of interior plaster, painted thickness, 9¾ inches; weight, 52 lbs. psf	Incombustible, with a fire-rating of four hours	Poor U value— .48	Some problems with soiling and weather-resistance	Used only in mild, dry climates because of condensation problems; weightbearing; expensive for framing windows	
4 inch concrete block, water-repellent paint on exterior 2 inch cavity (air space) 4 inch concrete block, painted thickness, 10 inches; weight, 46 lbs. psf		Incombustible, with a fire-rating of three hours	Fair U value— .28	Fair, some soiling	Limited weightbearing capacity; expensive for framing windows; good interior acoustical finish	
	4 inch exterior face brick 2 inch cavity 4 inch common interior brick with ¾ inch layer of plaster, painted thickness, 10¾ inches; weight, 48 lbs. psf	Incombustible, with a four hour fire-rating	Fair U value— .27	Fair	Limited loadbearer; expensive for framing windows	

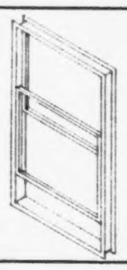
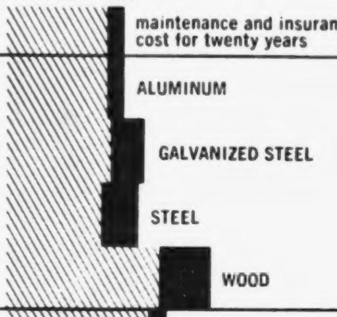
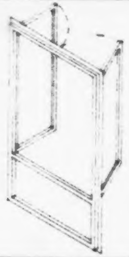
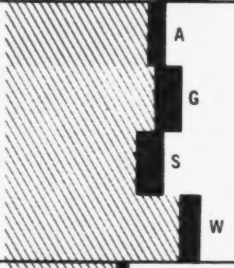
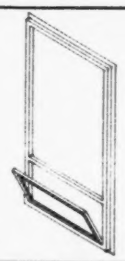
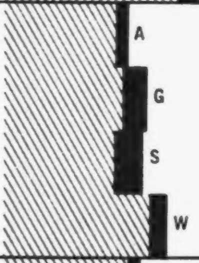
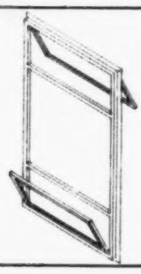
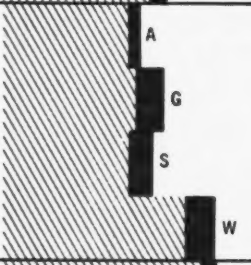
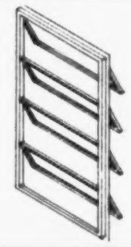
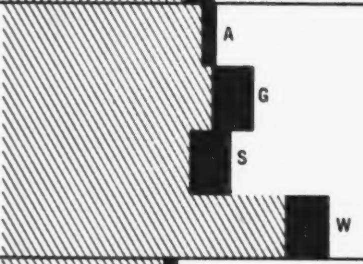
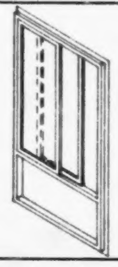
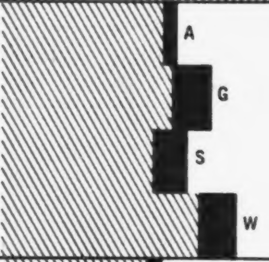
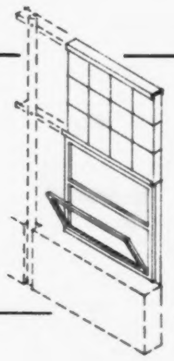
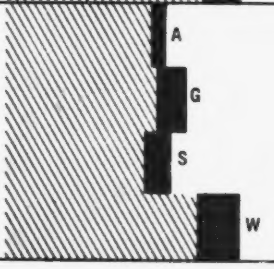
EXTERIOR WALL CONSTRUCTION continued

DRAWING AND DESCRIPTION	FIRE-RATING	INSULATING QUALITY	MAINTE-NANCE	REMARKS	COST COMPARISON
 4 inch exterior face brick 2 inch cavity 4 inch concrete block, painted thickness, 10 inches; weight, 46 lbs. psf	Incombustible, with a four hour fire-rating	Fair U value— .28	Fair	Limited loadbearer; somewhat expensive for framing windows	
 8 inch face brick, damp-proofing 2 by 2 inch furring strips, spaced 16 inches apart metal lath and plaster, painted thickness, 10¾ inches; weight, 52 lbs. psf	Incombustible, with a fire-rating of four hours	Good U value— .15	Fair	Weightbearing; good condensation control; somewhat expensive for framing windows	
 1 inch cement stucco on lath and building paper ¾ inch composition board sheathing 2 by 6 inch wood studs (spaced 16 inches apart) with 4 inch mineral insulation layer between gypsum rocklath and plaster, painted thickness, 8½ inches; weight, 30 lbs. psf	Fire retardent, with a fire-rating of about ¾ of an hour	Very good U value— .10	Poor, some soiling, poor endurance	Limited loadbearing; easy for framing windows; very good condensation control	
 ⅜ inch waterproof plywood, stained, and building paper ¾ inch insulation board 2 by 6 inch wood studs, spaced 24 inches ½ inch composition board ¾ inch interior grade plywood, stained and waxed thickness, 8 inches; weight, 15 lbs. psf	Combustible	Fair U value— .24	Fair	Limited loadbearing; easy for framing windows; a fast wall to build	
 ⅞ inch wood board-and-batten, oiled or stained finish, and building paper ¾ inch insulating board 2 by 6 inch wood studs, spaced 16 inches ½ inch wallboard, with taped joints, painted thickness, 8 inches; weight, 15 lbs. psf	Combustible	Good U value— .20	Fair	Limited loadbearer; windows are easily framed; a fast wall to build	
 2 inch asbestos-cement composition panels, held in aluminum grid, and building paper 2 by 6 inch wood studs, spaced 24 inches ½ inch wallboard ⅜ inch composition panels, painted thickness, 8½ inches; weight, 14 lbs. psf	Combustible	Good U value— .15	Good	Limited loadbearer; windows are easily framed; asbestos-cement is somewhat brittle to handle, but wall can be built quickly	
 1 inch stucco on self-furring lath, and building paper ¾ inch composition board sheathing 4 inch nailable steel studs, spaced 24 inches apart gypsum lath board and plaster, painted thickness, 7 inches; weight, 32 lbs. psf	Incombustible, with about a ¾ hour fire-rating	Fair U value— .22	Fair	Limited loadbearer; easy for framing windows	
 16 gauge extruded aluminum sheathing "sandwich" panel of 1½ inch rigid insulation, clad in 18 gauge steel (primed and painted) thickness, 3½ inches; weight, 6 lbs. psf	Incombustible, but still not rated in many building codes	Good U value— .15	Good	Nonloadbearing; these prefabricated components become a "curtain wall" hung on framing; very light, can be built quickly; unlike most of the other walls, the price with windows will be lower than that for solid wall (given right)	

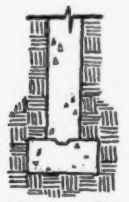


DRAWING AND DESCRIPTION	FIRE-RATING	INSULATING QUALITY	MAINTENANCE	REMARKS	COST COMPARISON
 "Sandwich" panel with 2 inch glass fiber core clad in 16 gauge galvanized steel, to be installed in steel frame with plastic gaskets, primed and painted, inside and outside thickness, 2½ inches; weight, 5 lbs. psf	Incombustible, but still not rated in many building codes	Good U value—.18	Good	Only fair provisions for condensation; easily demountable, wall can be built quickly; windows can be inserted with ease; price (psf) with windows actually will be lower than price for solid wall, given at right	
Ventilated "sandwich" panels with 2 inch glass composition core plus air space, clad in porcelain-enameled aluminum or steel facing interior galvanized steel facing panels installed in aluminum frame with glazing beads and plastic gaskets thickness, 2½ inches; weight, 5 lbs. psf 	Incombustible, no time-rating	Good U value—.15	Good	Can be made to bear load by strengthening frame; a prefabricated component, it facilitates construction, and can be removed easily to revise building; cost of wall with windows will be less than cost of solid wall shown at right	
 "Sandwich" panel with core of foamed plastic or composition glass, 2 inches thick, sheathed in aluminum or steel porcelain enamel exterior finish installed in aluminum frame with glazing beads and plastic gaskets thickness, 2½ inches; weight, 5 lbs. psf	Incombustible, but still not fire-rated in many areas	Good U value—.15	Good	A prefabricated panel, it is easily mounted when building, demounted when remodeling; frame can be strengthened to become loadbearing; cost of walls with windows will be less than cost of solid wall shown at right	
⅞ inch clapboard siding, finished with primer and paint, and building paper ¾ inch insulation board 2 by 6 inch wood studs, spaced 16 inches 3 inch mineral wool insulation between studs ½ inch wallboard with taped joints; painted thickness, 8½ inches; weight, 16 lbs. psf 	Combustible	Very good U value—.12	Fair	Limited loadbearing; easy for framing windows	
 Natural stone, 12 inches thick vapor barrier 2 by 2 inch furring strips metal lath and plaster, painted thickness, 15 inches; weight, 125 lbs. psf	Incombustible, with a fire-rating of four hours	Poor U value—.30	Good	A handsome wall if the right mason is chosen and given enough time; loadbearing, permanent, inflexible; difficult for framing windows	
4 inch exterior face brick 6 inch concrete block, and vapor barrier 1¾ inch metal lath and plaster, painted thickness, 11¾ inches; weight, 54 lbs. psf 	Incombustible, with a fire-rating of four hours	Poor U value—.30	Good, soils somewhat	Loadbearing; expensive for framing windows; good condensation control	
 Window-wall with one thickness of "double-strength B" glass in a 4 inch wood frame, with an operating hopper at top or bottom thickness of glass, ⅛ inch; weight, 2 lbs. psf	no rating	Very poor U value—1.14	Poor	A good wall in moderate climates, but one which demands careful shading from heat and glare; poor condensation control; poor acoustically	
Welded, double-glazed window wall, with two layers of "double-strength" glass separated by partial vacuum in 4 inch wood frame, with hopper at top or bottom thickness, ½ inch; weight, 4 lbs. psf 	no rating	Poor U value—.67	Poor	A handsome wall if used appropriately in moderate climates; needs shading; good condensation control; fair acoustically	

WINDOWS

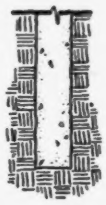
OPERATION		VENTILATION	REMARKS	COST COMPARISON installation cost maintenance and insurance cost for twenty years
Double-hung window: upper and lower sections slide vertically to open; spring balance; lock at meeting rail		Substantial airflow, but not directed well; drafty without a shield	No parts project even when open; sometimes difficult to open if schoolroom has usual shelving at sill level; usually a glass deflector is installed to prevent drafts	
Casement window: with fixed glass section at bottom, two swing-out sections at top; crank-operated		Substantial airflow, but not directed well; drafts are difficult to avoid	Easily operated; shades can be drawn without obstruction when window is open (but they will billow in breeze); these windows must be placed carefully—there is danger of children running into them outdoors if open; rarely used in schools	
Projected window: with fixed upper section of glass, vent (hopper type) at bottom opening in; crank-operated		Adequate airflow in most climates; well directed, not drafty	Easily operated, can be used with shades or blinds closed over most of its area; view is unobstructed, even when window is closed	
Projected window: with sections opening out at top, in at bottom; crank-operated		Very good airflow, both in quantity and quality (not drafty)	Easily operated; does provide some ventilation even when partially shaded; view through this type is almost unhindered with few obstructions at eye level	
Awning window: four horizontal sections project out; crank-operated		Large quantities of airflow are easily controlled, with fairly good draft control	Can be opened quite wide even during rainstorms; is easily operated; shades can be drawn without obstruction; framing does obstruct outdoor view somewhat whether window is open or closed	
Sliding window with lower fixed section		Substantial airflow, but hard to control, drafty	No parts project either inward or outward when open, but window is sometimes difficult to slide with the usual schoolroom shelf at sill level	
Combination window: upper section is of glass block, supported on angle and channel girts attached to columns; lower section is half fixed glass, and half hopper (crank-operated)		Adequate, well directed air flow for most climates	Some types of glass block refract light to ceiling, providing good light distribution across classroom and eliminating need for shades or blinds; however, designer must take care to use properly; this type does not always meet brightness tests for good schoolroom lighting	

Beware of simplified construction which omits the sash and sets glass directly into the structural frame which is cut to size, put together, and fitted on site. The workmanship of such installations will rarely match that of sash fitted, glued, and doweled in the shop. If it is steel frame fitted at the site, the jointing gasketing requires exacting workmanship that one cannot expect to be done in the field. Stick to standard sizes and arrangements of sash.

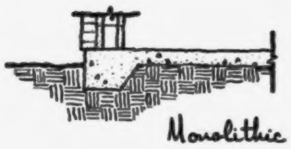

Foundation With Footing

Foundations In one- or two-story structures, imposed loads are relatively light and thus foundations are light. Even so, foundations which are designed for imposed loads, rather than according to arbitrary practice, can effect savings and will at the same time give more uniform support. There has been a good deal of experimentation in eliminating wall footings where light loads are involved.

In the case of the traditional footing and foundation wall (Case 1), earth must be excavated to the width of the footing and backfilled after construction. In Case 2, a trenching machine can be used, with no backfill—a quick and clean operation. Obviously, the soil must be capable of supporting the loads imposed by the narrower wall footing. If drains must be placed about the periphery of the building much of the advantage is lost. Nevertheless, this approach will lead to a faster job with less material.


Foundation Without Footing

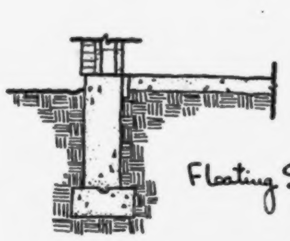
With stable soil conditions, a slab-on-ground construction is a most economical method of floor construction. It has been used for many years; the old basement floor is a slab on ground. Slab problems are legion—moisture protection, insulation, and the need for reinforcement—but they are being solved daily. The reasons for economy are obvious; the ground (or fill) helps give uniform support to the floor itself and the loads imposed. The same slab built off the ground would require much more steel, form work, and, in most instances, more concrete.


Monolithic Slab

There are two basic types of slabs; the monolithic and the floating.

The monolithic provides floor and foundation all in one; it is, however, limited in application to light loads and good soils. It is not ordinarily satisfactory in cold climates, because of the impossibility of supplying edge insulation which can be done in the case of the floating slab.

Slab construction normally requires provision of a depressed tunnel, incorporated into the slab design, for service conduits for plumbing and often heating and wiring.


Floating Slab

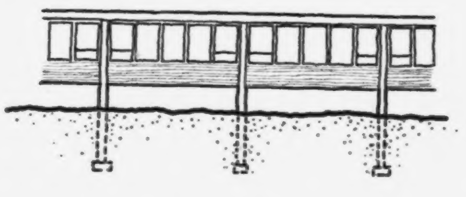
There are conditions under which it is more desirable to lift the building off the ground and to use isolated column footings for support. Generally when this is done the loads will be totally supported by the frame and the costs will be higher. The frame must be able to carry the additional floor loads, and it must be securely braced. The savings in footings or foundation walls probably will not offset these costs.

Mechanical System

The mechanical facilities of the school, i.e., the heating, ventilating, electrical, and plumbing systems, will represent close to one-third of the total of the school building cost, according to EFL's school cost survey.

Each of these systems involves:

FIXTURES Heating units, fans, blowers, lighting fixtures, hot water units, toilet fixtures.


Isolated Column Footings

CONDUITS Piping, wiring, ducts, and the channels to carry these conduits.

RELATED BUILDING MATERIALS AND DETAILING Floor and wall surfaces for lavatories. Wall surface materials and colors will affect the illumination.

For maximum efficiency, all of the choices involved in the design of the mechanical system need to be viewed as a whole. The visual, thermal, and acoustical environments are all interrelated. Moreover, the space requirements of the fixtures and the conduits can be planned to fit the basic structural system with greater or lesser efficiency in terms of installation, maintenance, repair, or replacement. Intensive study is needed to minimize the lengths of runs and costly bends and to yield the most efficient fitting.

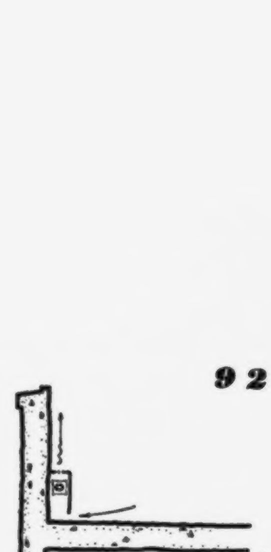
Two approaches are increasingly employed to achieve efficient mechanical systems. One of these, the service core approach, is to locate the main conduits and fixtures in a specially designed and easily accessible system of interconnected spaces, attempting to minimize the use of spaces inside walls or between ceilings and floors except for service to individual rooms. The other, the space module principal, is to incorporate the conduits—so far as possible—into the floor, external walls, and ceiling spaces. One of the aims is to locate service outlets at standardized distances from each other so as to permit a wide range of choices in the partitioning of areas—but with the partitions always at preplanned intervals. The space module measures are used for the purpose of establishing standard structural intervals—such as widths and thicknesses of studs and joists, distance between them, standard sizes of building panels, and standard widths and heights of doors and corridors. All of these standards are the very essence of loft arrangements but should be considered for other applications as well.

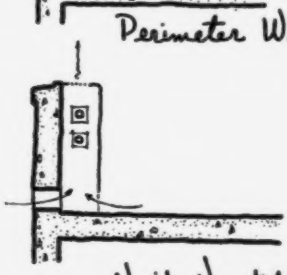
Heating Heating systems can be classified as either "dry," i.e., air, or "wet," i.e., steam or hot water. Although these systems may be divided into many special categories, only a few are currently used to any extent in schools. These are perimeter wall convectors (which may be either steam or hot water), floor panel heating, unit ventilators, and high and low velocity air systems. Perimeter convector and floor panel systems usually involve a separate system of mechanical ventilation, whereas the other types normally include provisions for mechanical ventilation along with the heating.

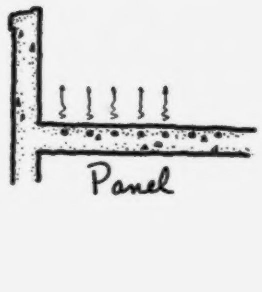
The degree to which the choice of heating system is bound up with other aspects of the building design is indicated by the following:

The extensive use of slab-on-ground construction has created a cold-floor problem in northern climates, particularly in the case of kindergartens where the children play and are expected to nap on the floor and where the typical flooring material is usually highly conductive. This has sometimes led to the use of floor panel heating as a solution to the cold-floor problem. But unless carefully controlled, floor heating often creates an opposite problem of overheating. Another solution lies in the choice of finish flooring material. Cork tile or carpet will eliminate the cold-floor problem almost completely.

Campus plan schools lend themselves to steam or hot water systems, so that the economy of a single central heating plant with underground heat distribution systems can be used. If it is difficult or expensive to


Perimeter Wall Convector


Unit Ventilator


Panel

obtain licensed engineers to operate the plant, then high pressure steam or high temperature water (350°F) which require an engineer would not be economical. Unit heating systems are also appropriate for this type of school, and at least one study has concluded that a unit heating system is initially cheaper than the central plant, employs less equipment and fewer motors, and costs less to operate. The choice of the most economical system will best be made only after careful individual analyses of comparative costs of installation, maintenance, and operation. For example, an important factor in the operating cost of unit heating equipment may be the relative cost of gas fuel.

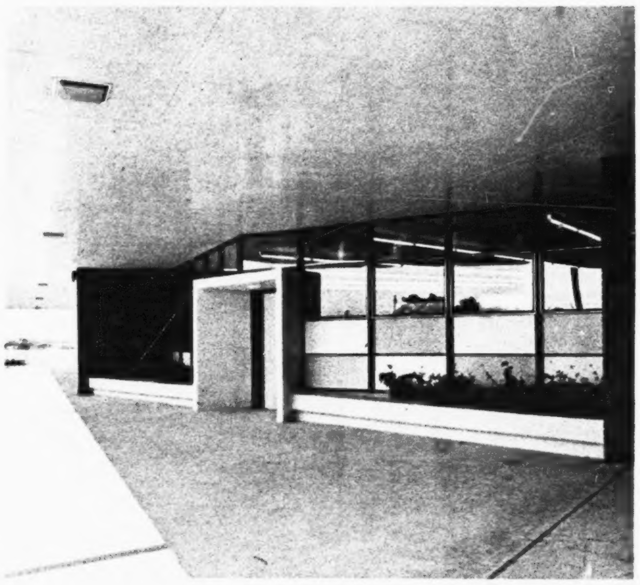
Many state codes set up a required minimum of ventilation for schoolrooms, usually on the order of 10 to 15 cubic feet per minute per pupil, for diluting odors and preventing excessive moisture-condensation on the windows and to overcome a tendency of classrooms to be overheated, due to heat gain from the pupils, the lighting system, and the sun. Effective ventilation is needed to prevent wintertime overheating. The problem is how to introduce cooling air without introducing drafts. So-called "open window ventilation" is certainly not the right answer, at least in the North. It allows chill outdoor air to enter the room directly, fall to the floor, and collect in a layer of cold air where it is most vexing around the feet. If your feet are cold, you are cold no matter how warm the room may be. Mechanical ventilation first tempers outdoor air with room air before discharging it into the upper part of the room, where it can further mix with room air before reaching the occupants.

The choice of heating system design is inextricably related to the problems of ventilation and cooling (with or without air conditioning). Two recent studies available to EFL indicate that there is little difference in initial cost between different systems. If you start to add power ventilation to the system, as you do in a central ventilating system with controls or in a unit ventilation system, the cost increases almost in direct linear proportion to the amount of ventilation which you attempt to do. On the other hand, to build a school without adequate provision for ventilation may be fatal to the purpose for which it is being built. There is an obvious coordination between alertness and reasonable heating and ventilation.

One method of saving on the cost of the heating system is to avoid over-design. Heating systems need not be sized for extreme conditions which may occur once or twice a year, but should be designed on the basis of the established outdoor design temperature for the area. Moreover, the minimum temperatures used in establishing these design standards usually occur only at night—suggesting that for school design purposes even these may be too high. Remember also that any heating system can be run above rated capacity for short periods. The *American Society of Heating, Refrigeration and Air Conditioning Engineers Guide*, a yearly publication, is the most reliable source of data on this subject.

Indoor temperature design conditions should be carefully selected. On all but a few heating days, higher temperature than design conditions can be maintained. In other words, say in the Washington, D.C. area, we can safely select an indoor design temperature of 60° with outdoor temperatures of 0° knowing that rarely, if ever, will the actual

The Belaire Elementary School, San Angelo, Texas. Caudill, Rowlett, and Scott architects. The first completely air conditioned school in the United States. The school is circular under its square roof.



outside temperature fall to zero. Consequently with a thermostat setting of 73°, except for a very few occasions, we can safely expect to maintain 73°. To design the system for a higher temperature than this would mean running it at much less than capacity on all but these few occasions, an inefficient design and an uneconomical operation.

The selection of two boilers for the heating system, where one is adequate for requirements, is seldom justified. Present equipment is reliable, breakdowns are rare, and repairs can be easily and quickly accomplished.

The control of the heating system involves the choice between manual or automatic controls. (This does not apply to automatic flame safety or boiler controls—these are an essential part of any system.) Secondary controls are expensive both in first costs and maintenance. There are those who maintain that the simpler the control system the more satisfactory the plant operation. They would zone areas in a school that are vacant for extended periods, such as the auditorium, but would use a simple manually operated zone control valve. The case for automatic controls is the case for the controlled environment. It is also related to the cost of maintenance services and the judgment that no maintenance man or engineer could possibly carry out so many sensitive operations so efficiently and economically. In this view, also, manual operation often tends to heat the school for longer before-school and after-school hours than necessary. Automatic controls can save fuel.

Selection of the type of fuel to be used for heating should be made after comparing costs of gas, oil, and coal (and occasionally electricity) for the particular school site. Cost of fuel alone is not necessarily the deciding factor. While the cost of fuel, on the basis of B.T.U.'s produced per dollar, should be considered, so should the cost of storage space, ash removal, and maintenance. While gas may be more expensive than oil in some areas, increased maintenance connected with oil-firing, storage tanks, pumps, and amortizing the additional cost of oil storage and pumps may tend to equalize the cost or even reverse apparent economies. The difficulty of making an intelligent choice is, however, compounded by the fact that no one can with certainty predict the comparative costs of fuels ten years hence.

At the present rate schedules, electric resistance heating has proved economical in only a few regions of the country. The increased availability of off-peak power, due to increased capacities created for summer air conditioning loads, may alter this situation and permit the economical use of individual room resistance heating.

Ventilation Ventilation is a twofold problem. Under winter conditions we wish to ventilate the room without causing drafts on the pupils, and in summer we wish primarily to cool the pupils by creating an air flow or draft. The quantities of air involved are greatly different. Normal practice provides at most six or seven air changes every hour for maximum wintertime ventilation, while the Florida regulations require an air change every two minutes for warm weather cooling. Winter ventilation for room cooling is best provided mechanically, but satisfactory warm weather ventilation has ordinarily depended on large window openings.

Mechanical exhaust ventilation should be used in toilets, lockerrooms, auditoriums, gymnasiums, and similar areas for the removal of concentrated odors and fumes. Such exhausts draw air from other parts of the school, neatly complementing the usual practice of supplying at least some air to the classrooms all of the time they are in use. Automatic controls for exhaust ventilation are costly and complicated and should be avoided. Simple on-off switches are adequate.

Air Conditioning Since schools have been ordinarily closed during the two hottest months of the year, air conditioning has not been considered except in the warmest parts of the country. With the increasing trend toward summer session and all-year use of school buildings it should be considered. Air conditioning is more easily adapted to forced hot air systems and systems using unit ventilators than to systems using perimeter convector heating.

It is difficult to get firm and final estimates of the additional cost of air conditioning a school. However, in Alton, Illinois, having been pleased with one air conditioned school, they planned a second one. Bids were taken for the building with the provision for future air conditioning (appropriate unit ventilators, insulated piping, space in the boiler room for a water chiller, etc.) and alternatively for the school with complete air conditioning. The architects estimated that the cost of the provision for future cooling was 20 cents per square foot. The cost of the air conditioning system was 50 cents per square foot. Consequently, the total cost of the system was 70 cents per square foot for the entire building. The school itself cost $14.14 per square foot. The cost of air conditioning was in the neighborhood of 5 per cent of the total cost of the school.

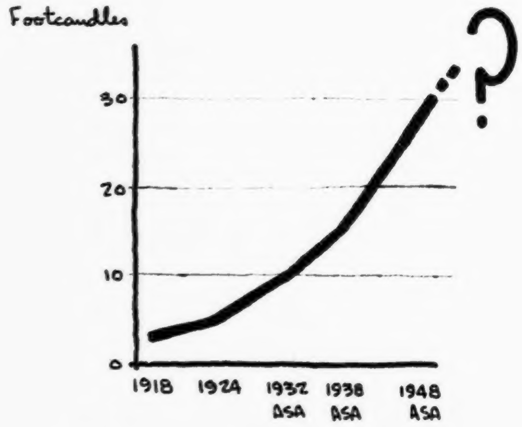
But it makes possible certain economies. A more compact plan is reasonable. Keeping windows closed reduces outside noise and at the same time increases interior background noise (from the ventilating units). This will raise tolerance for sound throughout the interior. Even if complete air conditioning is not to be provided at the outset, the heating and ventilating system and other aspects of building design (including means of dealing with condensed moisture in the case of unit ventilators) can be planned for conversion to hot weather cooling.

Lighting This is the aspect of building design for which standards have been raised in the most revolutionary way, due without doubt to an intensive educational campaign financed and intelligently conducted by the electrical industry. To illustrate the rapid rise of these standards, the 1943 Massachusetts Department of Public Safety Regulations say, "Artificial lights when used shall provide illumination . . . equal at least to the minimum intensities specified . . . and may be by electricity or gas, or by oil lamps . . ." The specific intensity for "Ordinary class, recitation and study rooms, library . . . and . . . laboratories in schoolhouses . . . 5 ft. candle."

In 1952 the Illuminating Engineering Society recommended the minimum footcandle levels for schools which are shown at the right of this page.

Today because of recent research new measurements for lighting are being worked on based on visual tasks to be performed rather than on rooms.

With universal acceptance of the principle that the quality of light is as important as the quantity, improved school lighting becomes

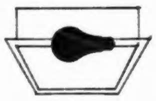
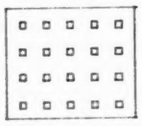
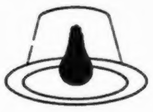
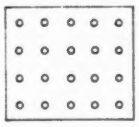
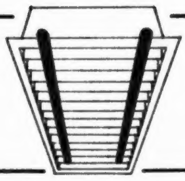
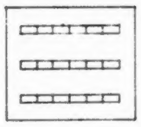
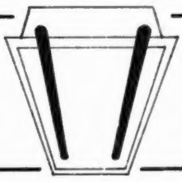
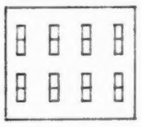
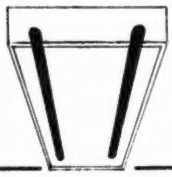
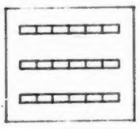
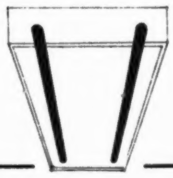
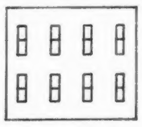
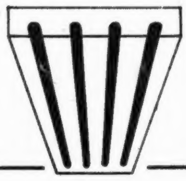
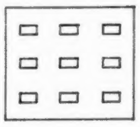
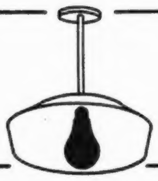
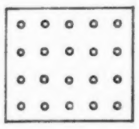
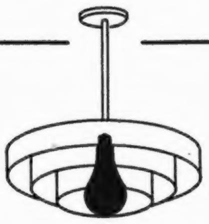
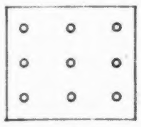
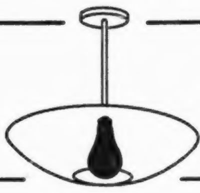
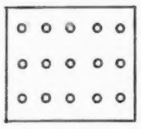
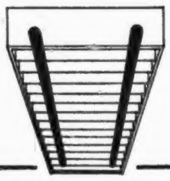
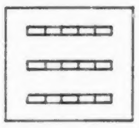
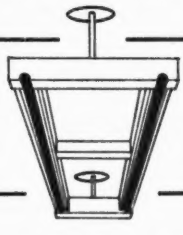
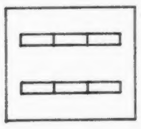
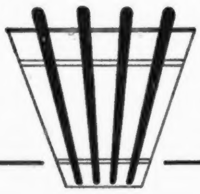
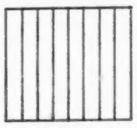


Minimum Recommended Classroom Illumination

Source: **ILLUMINATING ENGINEERING,** Illuminating Engineering Society, Vol. LV, No. 1, January 1956, p. 37.

Place	*Footcandles*
Classrooms—on desks and chalkboards	30
Study halls, lecture rooms, art rooms, offices, libraries, shops, and laboratories	30
Classrooms for partially seeing pupils and those requiring lip reading—on desks and chalkboards	50
Drafting rooms, typing rooms, and sewing rooms	50
Reception rooms, gymnasiums, and swimming rooms	20
Auditoriums (not for study), cafeterias, locker rooms, washrooms, corridors containing lockers, and stairways	10
Open corridors and storerooms	5

LIGHTING

TYPICAL FIXTURES		CEILING PLAN
	Direct lighting; square fixture with lens; 20 fixtures of 200 watts each	
	Direct lighting; round fixture with lens; 20 fixtures of 200 watts each	
	Direct lighting; louvered troffer with 30 by 35 degrees shielding; 18 fixtures of 100 watts each	
	Direct lighting; diffuser troffer; 16 fixtures of 100 watts each	
	Direct lighting; translucent plastic enclosure; 18 fixtures of 100 watts each	
	Direct lighting; lensed fixture; 16 fixtures of 100 watts each	
	Direct lighting; translucent plastic bottom, with four 48 inch lamps; 9 fixtures of 200 watts each	
	Direct-indirect lighting; enclosed globe; 20 fixtures of 200 watts each	
	Indirect lighting; concentric ring with silver bowl lamp; stem at least 30 inches; 9 fixtures of 500 watts each	
	Semi-indirect lighting; glass bowl, stem at least 30 inches long; 15 fixtures of 300 watts each	
	Semi-direct lighting; louvered bottom with 35 by 25 degrees shielding; 15 fixtures of 100 watts each	
	Semi-indirect lighting; plastic bottom panel; stems at least 30 inches long; 6 fixtures of 264 watts each	
	Luminous ceiling; 9 rows of 7 lamps; 63 fixtures of 50 watts each	

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Walter McQuade, Simon and Schuster, N. Y., 1958
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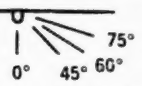
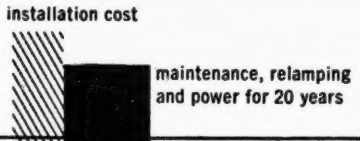
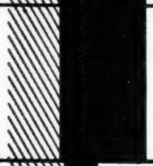
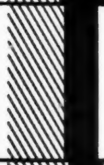
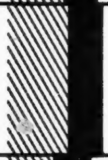
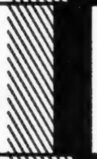
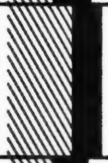
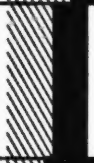
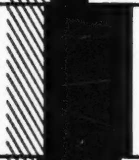
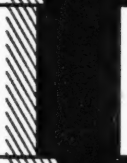
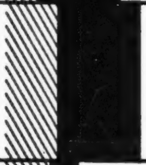
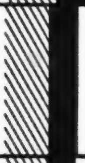
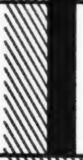
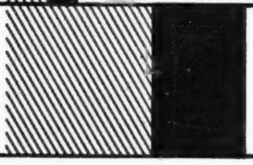
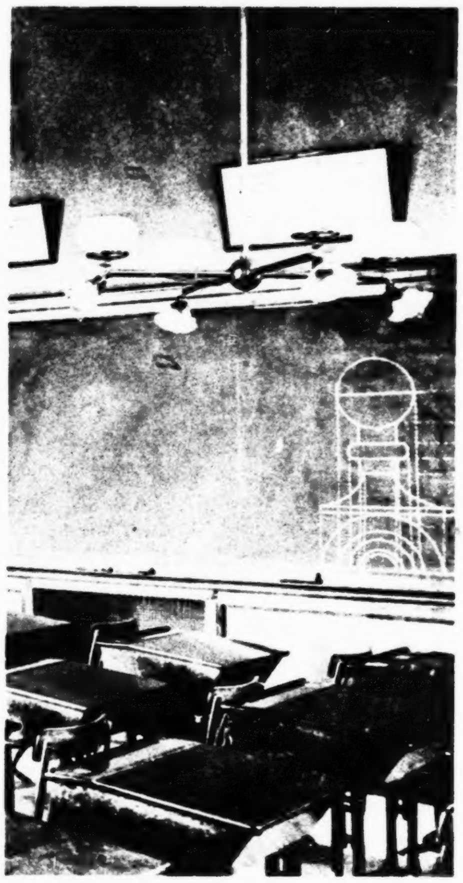
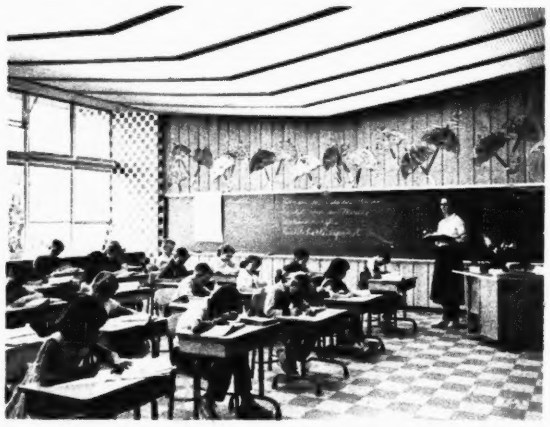
FIXTURE BRIGHTNESS (in foot lamberts) 75°	 60° to 45°	22½°	BRIGHTNESS AT DESK LEVEL (in foot candles)	LAMP LIFE (in hours)	POWER REQUIRED (in watts)	REMARKS	COST COMPARISON
400	800 to 2200	3400	29.5	750	4000	The brightnesses of these fixtures are generally high; operating costs are also high; a suspended ceiling is required to house these; the heat they radiate may also be a problem in warm weather	
400	800 to 2200	3400	31	750	4000	The brightnesses of these fixtures are generally high; operating costs are also high; a suspended ceiling is required to house these; the heat they radiate may be a problem in warm weather	
500	700 to 1250	1800	32.3	7500	1800	Fixture brightness is high; ceilings are dark; installation costs are high (a suspended ceiling is required); this fixture creates reflected glare problem; eggcrates like these are difficult to clean	
600	800	800	29	7500	1600	Fixture brightness high; ceilings dark; installation costs are high; brightness high in direct glare zone	
800	800 to 1300	1400	28	7500	1800	High fixture brightness; overly contrasting ceiling patterns	
600	1600	2000	33.8	7500	1600	High brightness values; initial cost of fixture is high, but operating costs are low	
1000	1200 to 1250	1250	30	7500	1800	High fixture brightness, especially in glare zone; if two lamps are used in this fixture, brightness is reduced but twice as many fixtures are required	
00 to 2000	1000 to 2000	1000 to 2000	29	750	4000	Brightness excessive and varies considerably, depending on size and shape of globe; rarely used in modern classrooms	
5 to 250	5 to 250	5 to 250	25.8	1000	4500	Low fixture brightness; good brightness patterns on ceiling; high wattage and operating costs, but with lowest initial cost; lamp life is low; easy maintenance; difficult to use this fixture on a low ceiling	
300	300	300	30.5	750	4500	If a relatively dense diffuser is used, brightness of fixture can be lowered; maintenance is difficult—the bowl is a dust catcher	
300	550 to 1500	1700	33	7500	1500	Ample light, but with excessive brightness (unless shielding is better than usual); poor pattern of light (unless supplementary lighting is provided); reflected glare is also bad	
225	325	350	30	7500	1600	Excellent brightness patterns; high efficiency; a relatively new type of fixture, developed to utilize new high-output lamps; becoming increasingly popular	
Brightness from various angles ranges from 100 to 200 foot lamberts in this continuous fixture (if lamps are at least 2 feet above plastic ceiling)			60	7500	3150	Excellent brightness patterns; difficult to maintain, requires frequent washing to remain effective; very high initial cost	



Lighting standards have changed



increasingly complex. The paradox of lighting is as follows:

- High intensity lighting is desirable.
- The higher the intensity, the greater the brightness (of the light source) and the brightness contrast (between light source and background).
- Brightness and brightness contrast are very undesirable.

The choice of the types of lighting may lie between:
Area lighting
Direct lighting
Indirect lighting
Direct—indirect lighting
Luminous ceiling.

Area lighting is for large spaces, such as gyms.

Indirect lighting and luminous ceilings overcome the lighting paradox by enlarging the area of light source to the dimensions of the entire ceiling, thereby reducing brightness to a tolerable magnitude even for very high intensities. Both types require additional heights, for which the building must be planned—indirect lighting requires increased ceiling height; the luminous ceiling requires an extra space (the cavity) above the ceiling (the diffuser). Both are well suited for use in remodeling old school buildings, where required ceiling heights are usually found and frequently constitute one factor of obsolescence. Indirect lighting is very expensive and quite inefficient for achieving high intensities, but lends itself well to decorative treatments. Luminous ceilings, using corrugated vinyl plastic diffusers, may fit more easily into an economy budget, but present problems of maintenance have not yet been solved (outside of commercial applications).

Direct lighting must be carefully designed for overlapping patterns and even distribution and as nearly uniform intensities as practicable without disturbing cross shadows. It cannot provide intensities comparable to luminous ceilings without exceeding limits of tolerance for brightness. For ordinary classroom heights the cost of direct lighting rises sharply when an intensity of 35 footcandles is exceeded.

The choices for lamps usually lie between fluorescent and incandescent lamps, except that luminous ceilings allow no choice; they can use only fluorescent lamps. Wiring and fixtures for direct, fluorescent lighting are usually somewhat more expensive to install but cheaper to operate than those for incandescent lighting. Direct fluorescent lighting provides uniform, reasonable, high-intensity illumination. It also releases substantially less heat per watt, reducing the ventilating load.

In the interest of operating economy, separate switches should be provided for the outside row of lights parallel to the windows. Elaborate expensive fixtures should not be used in public areas. Fixtures should not be selected solely on the basis of easy cleaning and relamping, but on the merit of lighting characteristics. Some of the alternatives are indicated in the lighting chart from *Schoolhouse*. Incandescent lamps should be used in rooms where lights are used intermittently and for short periods of time and where high intensity illumination is not required. Simple industrial fixtures can be used in service areas. Recessed fixtures ordinarily cost more to install than surface types.

Any consideration of lighting without companion consideration of painting and color of the surround is a snare and a delusion. Bright lights sparkling in a dark surround are worse, from the standpoint of conditions for seeing, than lower intensities in a balanced environment. Consider the whole surround, the glare and reflections, not just how many footcandles of raw light are preferred. At the rate that recommended intensities of light are climbing, with some authorities claiming that 70 footcandles are optimum for school tasks, it is foreseeable that schools will retreat from trying to provide light solely from the plane of the ceiling and instead introduce spot arrangements of high intensity in particular portions of a room. Indeed it is quite likely that the homelike floor lamp or wall spotlight will find a place in the classroom of the future, to provide prescribed intensities of light for special tasks and to avoid unmanageable heat from a ceiling that has become a cooking as well as a lighting mechanism. Remember you are buying seeing. This can be a different thing from the simple purchase of mounting quantities of electricity. Therefore look at the whole environment, not just the footcandles.

Plumbing Since the cost of plumbing usually moves within such a narrow range between what is required by local code and what may be considered luxury, the number and location of fixtures being the only variable, it presents little opportunity for significant savings. (As for conspicuous wasting of the tax money, the elimination of restrictive codes, which under the guise of health considerations perpetuate antiquated trade practices so as to preserve on site jobs, deserves examination.)

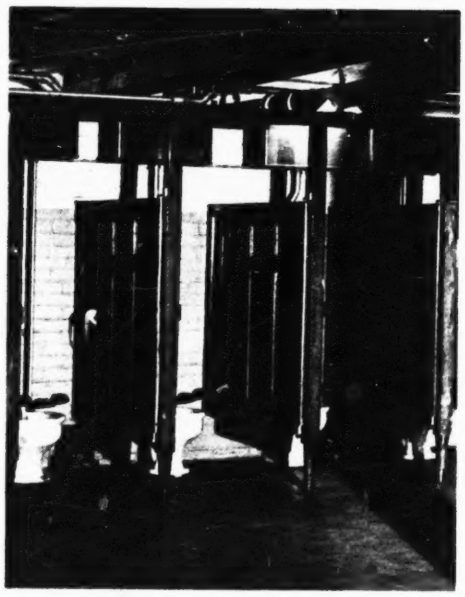
For the austerity budget, only the minimum number of toilets and fixtures in compliance with local codes should be supplied. Experience has shown that there has been a tendency to be lavish in supplying extra fixtures in toilets and shower rooms. The single most important factor in determining the number of toilets required in a school is the faculty attitude toward toilet-going. If the attitude is permissive, fewer toilets are needed. If toilet-going is scheduled at specific times, en masse, more toilets are required.

If it is considered to the advantage of the classroom that children (in the lower elementary grades) should not have to go down the corridor to use the toilet, then individual classroom toilets will be the logical and not very expensive choice. Similarly if the educational program requires sinks in every classroom, such small amenities of teaching will represent relatively insignificant additions to the total cost of building, and real value will be added to the school program.

For the austerity budget separate toilet facilities for the principal or teachers may often be eliminated in small secondary schools. But, where they are located adjacent to major toilet facilities or are located on the main water and sewer connections, they do not cost an excessive amount.

Insulation of domestic waterpiping is rarely required unless it is located in unheated spaces in the outside air or above the frost line. Where a boiler is used for heating, domestic hot water may be obtained as a by-product, with provision of a small separate water heater to supply hot water when the heating plant is not in operation. Avoid the use of blending valves, use heat exchanges to accomplish the same purpose.

The plumbing requirements for special science rooms should be carefully considered. Elementary programs seldom justify the same special laboratory sinks and plumbing necessary for more advanced science work. For elementary schools, the use of portable science demon-



. . . and so have plumbing standards.

stration carts which allow a greater flexibility of school program should be considered.

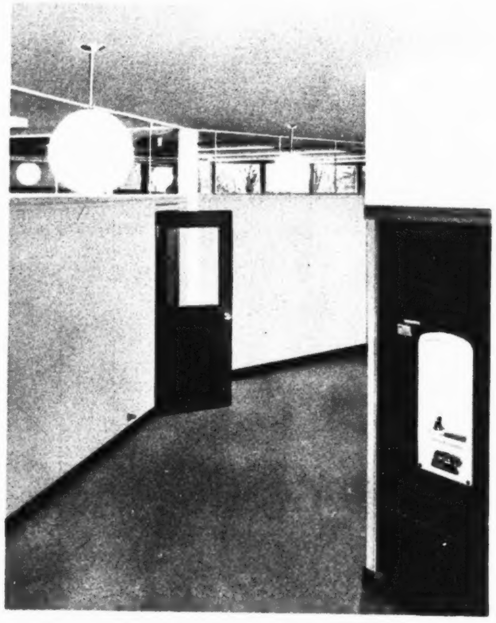
The use of nonferrous water-supply piping such as copper tubing is recommended. Smaller pipe sizes are required and labor installation costs are lower. Threading of piping is eliminated and lighter pipe hangers may be used.

Interior Surfaces

On the basis of EFL's survey, the cost of interior wall partitions amounts to nearly one-sixth of the cost of the school building. Costs of partitions plus ceilings, finished floors, and built-ins (and including painting) amounts to nearly one quarter of the total cost.

Yet clear cost advantages are difficult to define because maintenance costs may be as important a consideration as initial cost. The following comments are suggestive of some of the choices and issues. They are far from exhaustive.

Movable partitions make it possible for the school to change without major alterations.



Interior partitions Opinions regarding interior partitions vary as much as their costs. There is a tremendous range of acceptable partitions. Essentially there are three issues in addition to cost: flexibility, acoustics, and esthetics. In many localities the least expensive classroom partition will be a lightweight aggregate concrete block, painted. This economy can be lost if care is not taken in locating conduits and pipes or if blocks are laid with fashionable stacked joints (all vertical joints in a straight line). Such walls present problems of sound transmission. Plastering on one side only or spraying with plastic on both sides will improve their acoustic qualities. But such walls, while they are acceptable to many, still remain esthetically unsatisfactory to some. One architect has written EFL describing them as ". . . a material fit for garages and basements, not for walls within which one wants to live, learn, or teach; rough and clammy to the touch, wet in summer, cold in winter, hard, characterless, etc., etc.; it cracks, it peels, it cannot be laid straight. Enough said."

Further, such walls do not provide the vaunted flexibility so often claimed. The statement that these walls can be "knocked out with a hammer" is fantasy—they are almost never destroyed. Once up, they are there for good; for who, without a feeling of guilt, will destroy or otherwise dispose of public property?

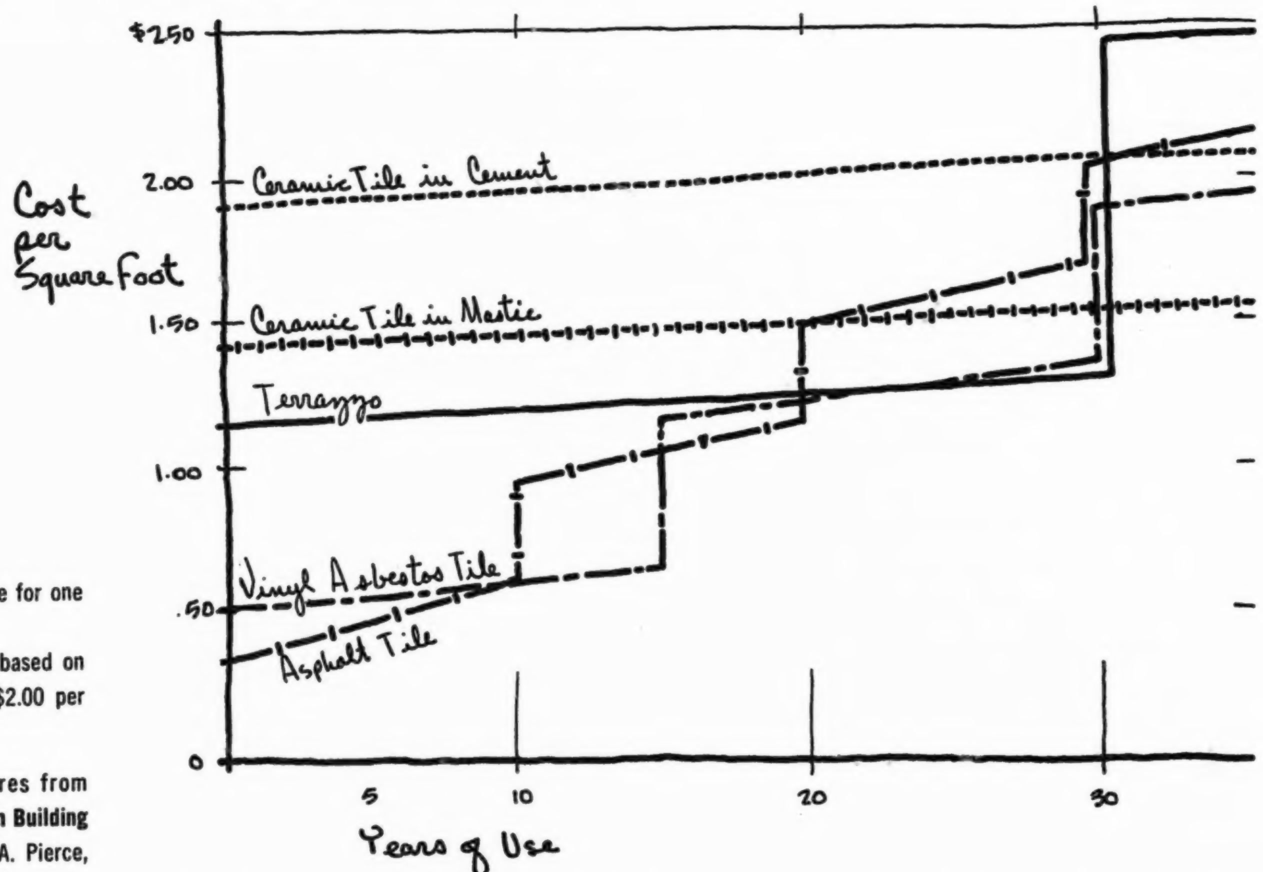
Steel studs or wood studs with half-inch thick dry wall applied with taped joints on each side provide low cost, acoustically satisfactory partitions.

Prefabricated metal partitions of the type ordinarily used in offices will be expensive initially, especially for good ones which provide the needed acoustic isolation. The additional cost will not be justified unless they will be moved several times in the life of the building. But at least their movement does not involve their destruction, for they are movable.

The amount of floor space occupied by the partitions should also be considered in looking toward economy, particularly in large schools where it mounts up. Protective surface treatment of at least the lowest third of interior walls is highly desirable or absolutely required according to the importance attached to maintenance. This protective wearing surface, the dado, should be of a material that does not soil, or show that it has been soiled, and should be easily cleanable. It should require no refinishing to be restored to its original condition. In other words, it should be impervious, hard enough to resist denting or scratching, but also pleasing to the eye in color and texture, smooth, warm, soft to the touch, and free of glare. Which of these conflicting requirements will be given preference will depend on whether the choice will be made from the point of view of the child or of the custodian—and each has valid claims for preference. In classrooms the dados may be, in the reverse order of their first costs: plywood, plastic (vinyl), or plastic laminate (formica). In corridors, in addition to these: ceramic tile, glazed ceramic units (glazed terra cotta), and glazed brick are often chosen. The cheapest alternate to all these, applicable to concrete block walls only, is the very serviceable vitreous spray coating. The desirability of ceramic tile for walls of toilet rooms, kitchens, and backs of sinks even in classrooms is well known. Applied plastic films may cost 75¢ or more per square foot. Their economy against paint at 6¢ per square foot is open to question. It is doubtful if their life will justify the difference.

Floorings Flooring offers perhaps the clearest and easiest to understand case study of low initial cost and high maintenance versus high initial cost and low maintenance. The graph on this page, the figures for which were taken from David A. Pierce's book, *Saving Dollars in Building Schools*, published by Reinhold, illustrates the issue. Pick any period of time and there will be a most economical flooring. But we cannot ordinarily know in advance the period for which the building will be

The Cost of 5 Different
Types of Flooring
Over 30 Years



Starting point includes installation cost and vertical steps include replacement.

NOTE: Prices are for one city.
Maintenance is based on labor costs of $2.00 per hour.

Based on figures from **Saving Dollars in Building Schools**, David A. Pierce, Reinhold Publishing Corporation, 1959.

used. Nor can we anticipate when major remodeling will occur. Furthermore, because the flooring materials industry is extremely competitive and continues to develop new, better, more economical, and more suitable floorings, we can look for considerable future advancement. The floor you wear out ten years from now will likely be replaced with a flooring not now available.

In classrooms and for general use, ⅛" asphalt tile floors provide good economy. The greaseproof type can be used in cafeterias. The premium cost of $\frac{3}{16}$" tile is not justified by additional length of life as tile is usually replaced because of cupping or brittleness before it wears through. The cost of vinyl asbestos tile is almost double. It is true that vinyl tile can be used without waxing for a while (usually not over six months), but once it has been waxed the cost of upkeep is about the same as for asphalt tile. Terrazzo floors cost more, last longer, are easier to maintain, and are probably only justifiable in halls. In certain sections of the country—notably Florida—terrazzo is substantially more economical. But again consider the suitability of the floor as well as first cost and long-term cost.

Some schools are experimenting with carpets.

Among the special purpose floors for toilet rooms and kitchens, ceramic tile floors are generally considered essential for long-term economy. Greaseproof asphalt tile kitchen floors can be twice replaced for the money spent on ceramic tile.

Quarry tile, long a favorite with uncritical kitchen planners, is made to stand up under the wheels of industrial trucks; its application in school kitchens wastes money on unused qualities unless food is routed from a central kitchen and brought in on trucks. Gymnasium floors of maple are ordinarily considered necessary for competitive games although they are expensive and costly to maintain.

For playroom use and for the elementary school gym cork asphalt pavement and plastic cork tile have lately entered the competitive field. The latter is a cork tile made with a plastic binder and is said to combine the softness, insulating qualities, and resiliency of cork tile with the permanence of an impervious plastic surface and with pleasing colors. Stage floors must always be nonsplintering soft wood, unfinished, which it is easy both to put nails into and to pull nails out of.

Vestibule floors, especially in a northern climate, must be nonslip, neither affected by water nor eroded by the daily rubbing-in of sand and clay or by the scuffing of black composition soles. Here may be the only economically justifiable use of slate, flagstones, brick pavement, or quarry tile; the smallness of the areas involved allows the best suitable flooring to be selected regardless of the cost. For storage rooms, shops, closets, receiving spaces, boiler-rooms, mechanical rooms, and other areas of hard wear where there is no need for appearance, trowelled concrete with a surface hardener should be used. It is uneconomical to paint concrete floors because of the need for frequent repainting. If a concrete floor is going to be painted for improved appearance, it would be more economical to install asphalt tile in the first place. Concrete floors are acceptable for use in corridors only if part of an extreme austerity budget.

Recently a large high school began to experiment with wall to wall carpets in classrooms and corridors. Contrary to general expectations, maintenance problems have not increased. Replacement will be simple, and a very substantial fringe benefit is derived by the reduction of noise. Comfort conditions may be materially improved by reducing the sensation of cold floors; heat loss through the floor and the time lag in bringing a room to comfort temperatures may be reduced. Apart from cost, carpeting would seem first choice for sections of kindergarten floors and other school floors as well, particularly the common room areas of secondary schools.

Ceilings There is a tendency to think of a ceiling as being merely the underside of something else (floor or roof above) which has been chosen for other considerations before the ceiling was thought of as such. This line of thinking sometimes lets the choice of ceiling deteriorate into a process of making the most of what we have.

Ceiling as the finished or unfinished underside of the framed floor or roof above provides economies on a limited scale. Occasionally the saving of the cost of a furred ceiling can be nibbled away if there is increased cost of finishing or painting the exposed framing members or fitting acoustic or other finish materials to the underside of deck or girders, or if there is extra expense for exposed piping and wiring and even duct work or installing lighting. If finishing materials such as acoustic tiles are used at all, their cost represents the greater part of any ceiling, furred or exposed. Nevertheless, the system employing a type of deck, the underside of which has acoustic properties, remains undoubtedly the most economical ceiling. Exposed structural members often contribute to the esthetics of the building. Furred and finished ceilings are the alternate choice, desirable in classrooms because they provide:

- Space between finished ceiling and framed deck in which to run pipes, wiring, ducts.
- Cheap insulation of an air space if it is roof above.
- Level unbroken surfaces, to which to apply finish, to space lighting fixtures, and to serve, if so designed, as a light reflector.
- A finished appearance.
- Furred ceilings of plaster or fire code plasterboard will sometimes add half to one-hour fire resistance to unprotected steel framing, which is rated at no resistance at all.

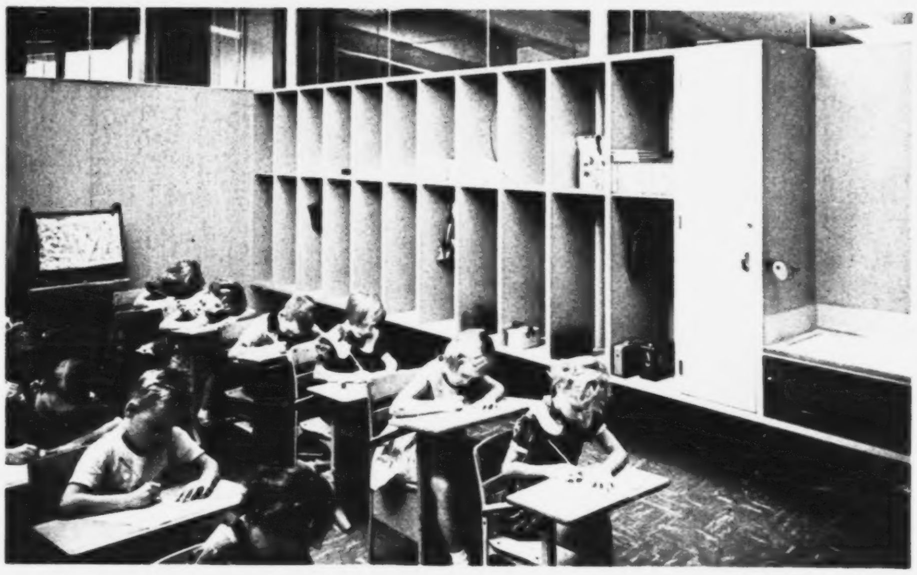
In gyms, shops, and large storage spaces there is no objection to omitting furred ceilings. But in small spaces, especially in closets and the like, it will often be found cheaper to provide a furred ceiling at a minimum height than to carry partitions and wall finishes up additional distances to the underside of the deck above.

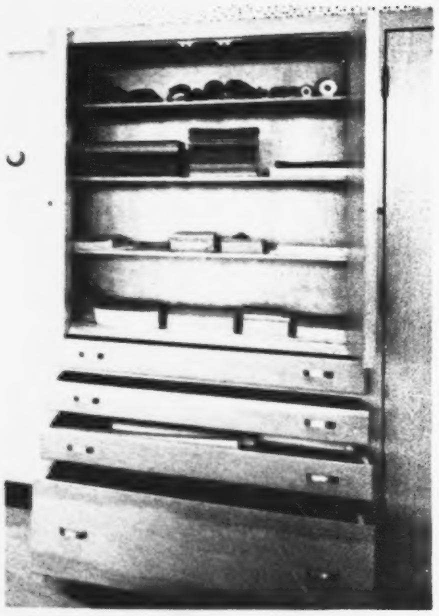
Wherever possible, furred ceilings should be kept at the same levels in adjoining spaces, indeed, in the whole classroom and administrative area of the building, both for the economy of framing and for allowing for future relocation of partitions without reframing ceilings.

Acoustic properties of the ceiling have been treated earlier.

The luminous ceiling (which uses the entire ceiling as one room-sized lighting fixture) is a special case of furred ceiling, and is discussed as part of the mechanical equipment.

Cabinet work and wood trim This is a substantial element of cost and offers many possibilities for economy. Chair rails, cornices, picture moldings, wood paneling, and mill-work built on the job are expensive and their need should be questioned. All cabinet work should





Don't Forget Storage and

Display Space

be of simple design. Doors and drawers should be omitted wherever possible. The identical unit should be repeated as often as practicable to facilitate economy in production. Items should be designed so that they can be made at the mill with a minimum of job fitting. Clear stock or hardwoods are usually not needed if the wood is to be painted.

Painting Economy in painting can be achieved by omitting paint in storage areas, boiler-rooms, closets, custodial spaces, and similar rooms. Expensive permanent finishes which eliminate repainting should be checked carefully as to their initial cost.

New plaster ceilings are better unpainted until the walls receive their first repainting, to allow the plaster to dry out more thoroughly. It is barely possible to detect that the ceiling has not been painted. Remember that paint is inextricably mixed with the question of lighting. The aim should be to make the whole environment perform to the maximum.

Unistrut—one system of modular building. Hoover School, Wayne, Michigan. C. W. Attwood, architect.

THE PROCESSES

The processes of contracting and building have a special impact on the cost of the building. The creation of a building is under the direction of the architect, but he usually employs for his work a structural engineer, a mechanical engineer, and perhaps other specialists. In some cases they may be working together for the first time. These specialized designers are often working in different offices away from each other. This contributes to problems of communication and coordination.

Ordinarily no one knows at the time the building is being designed who will build it. The specialized knowledge of up to the minute product and labor costs which the future contractors and subcontractors have is not usually available to the architect in any formal way, although he may explore cost factors with builders informally while developing his plans. For these reasons, the way in which certain steps in the complicated process of contracting and building are handled can affect the total cost.

Prebid Checking

It is of the utmost economic importance, regardless of who is responsible for delay, that plans not be put out for bids until they are thoroughly checked and coordinated. Change orders with cost penalties can be a serious factor in running up costs. Initial bids may be higher as contractors will allow more for contingencies if plans are not clear.

Alternates

The use of alternates in the plans and specifications is helpful only if wisely handled. Alternates should be used to find out the comparative costs of new or experimental building methods or materials. To get the most out of alternates they should be clearly and precisely defined. They should always be additions to the base-bid and designed to take advantage of possible market fluctuations or availability of materials. Deductive alternates are usually not as accurate.

The quantity of alternates should be generally limited in fairness to the bidders. It requires considerable time and effort to figure them. Builders object to alternates because they confuse and complicate their job of estimating.

For this reason many contractors say alternates increase bid prices by forcing the contractor to allow more liberal amounts for contingencies. In drawing up bid prices the contractor relies heavily on subcontractors; with numerous alternates the process, already difficult, becomes almost unmanageable. Therefore, use alternates sparingly if at all, and only for good reason.

Choice of Bid Time

Considerable economy can result from asking for bids at the most advantageous time. Unfortunately school planning and construction schedules seldom permit much speed up or delay to meet such a time. Usually the late fall or winter, when contractors may be low on work, is a good time. Contracts awarded early in the year permit getting the building enclosed before the next school year arrives. Knowledge of local situations will be more helpful than generalizations here. Where possible, jobs should not be let out for bid at the same time as other large work in the area. The preparation of a bid is hard and time-consuming work; the average contractor has great difficulty in handling more than one at a time.

Time Allowed for Bidding

Inadequate time to prepare bids will probably increase the price quoted substantially. Each contractor must assemble quotations from many subcontractors. Limited time will probably limit the number of subcontract figures and may increase contingency allowances.

Types of Contract

Some states require that the mechanical trades and perhaps others be awarded as separate contracts. This is promoted and favored by subcontractors who are thus relieved of the "bid-shopping" pressure of the general contractor under the single contract system. The general contractors naturally favor the single contract.

The split system deprives the general contractor of the opportunity to select subcontractors, not merely those who will bid the lowest price but with whom he knows what his relations will be. In effect, he loses control over his subcontractors both from a time and performance standpoint. Split jobs usually take longer to complete; hence the general contractors will include in their bid figures greater allowances for "General Conditions" and for contingencies. The split contract is an inefficient intrusion in a building process in which coordination and control are keys to economy.

To get work completed by a certain date, the so-called bonus and penalty contractual clause is sometimes used. This provides a per diem penalty if work is not completed by that date with a per diem bonus if completed ahead of that date. This clause is difficult to administer equitably. Time out is usually allowed for bad weather and for delays caused by changes in plans. The interpretation of "bad weather" or how many days should be allowed for a change in plan becomes a matter of opinion, as does the exact interpretation of when the building is completed. This type of contract clause is usually expensive, causes bad feelings on the job, and often contributes little to the swift execution of the work.

Clerk of the Works

Besides the supervision of construction by the architect or someone from his staff, the school board should employ a qualified and experienced person to supervise the construction on a day-to-day basis, to make sure plans and specifications are being followed by the builder. This supervisor should be responsible to the board, although he should report his findings directly to the architect for action. If adequate action by the architect is not taken, the clerk should report this to the board.

Equipment

It has generally been found economical to have the equipment which is built into the building specified by the architect and purchased and installed by the general contractor. This would include built-in cabinet work, built-in kitchen equipment, and the lighting fixtures. This pinpoints the responsibility for insuring proper fit, correct delivery time, and coordination of the installation, especially if more than one trade is involved. It also fixes responsibility for improper operation.

Some school boards have successfully handled some of this equipment outside the building contracts, but only when they have an unusual person on the staff who has the ability, experience, and time to insure efficient purchasing and satisfactory installation. The fee collected by the architect and the builder for this service is usually justified.

On the other hand, all stock movable educational equipment should be purchased by the school purchasing agent, superintendent, or principal and should not be delegated to the architect. Quantities should be carefully and accurately determined to avoid overbuying. Stock items should be used whenever possible, and cabinets should be simple but well constructed.

COMPARING SCHOOLS AND THEIR COSTS

In recent years, the comparing of school costs has taken on the aspect of a national pastime. Since the schoolhouse is the most public building in America in its conception, planning, and financing, school economy is an understandable matter of public concern. But quick, glib comparisons of school costs generate more sparks than electricity in the ever-raging debate on school costs—a debate, incidentally, almost always predicated on the notion of the schoolhouse as storage space for education. Productivity rarely enters into the cost question. Yet, while it is the hardest element to weigh, it is the basic factor. How does the schoolhouse contribute to the process which it contains?

Communities, like individuals, vary in their needs, in what they want, and in what they can afford to pay for their schools. What it costs to build a school depends first on the kind of educational program planned, and second upon the kind of schoolhouse wanted to accommodate this program. Each community must face these questions first. They must be weighed in terms of the community's educational aspirations and needs and what it can afford.

Getting the most for the school building dollar does not mean cutting the educational facilities to a bare minimum. Misunderstanding on this point has contributed greatly to the confusion about economy in building schools. The question of *what facilities are provided* can and should be distinctly separated from the question of *the economy* with which any given set of facilities is constructed. The first is a problem in values and philosophy. The second is a problem in building design, construction, and finance. Of course, there is an interrelationship—a very significant one—which accounts for there being some schools of poor construction but with good provision for program, and others of good construction but inadequate facilities.

Too frequently we hear of *comparisons* of the *cost* of schools without any effort to *compare the schools*. We can no more compare school costs without comparing the schools than we can compare home costs without comparing homes. All schools are not alike, nor should they be.

What are some of the measures commonly used to compare school costs? The most common is cost per square foot. Unfortunately, it leaves a great deal to be desired: first, because it doesn't indicate anything about the *quality* of materials and construction, which add up to the square foot cost, and second, because it doesn't relate to the usefulness of the space described.

Another one of the more common measures is *cost per pupil*. But unless we use a uniform method of determining how many pupils a school will accommodate and that they have the same type of educational facilities, this measure is of limited usefulness. There are, of course, various ways proposed for standardizing this measure of capacity but none have been uniformly adopted. Class size alone makes a substantial difference—switch from 40 to 24 pupils per classroom and capacity drops 40 per cent while costs per pupil jump 67 per cent. Add an auditorium, music room, and library and costs go up, but so does the program.

Another unit in common use is the *cost per classroom*. Here, the total cost is divided by the number of classrooms. But since the total cost may include such spaces as auditorium, library, music rooms, conference rooms, or gyms, a high unit cost could mean a generous number of these areas or it might mean merely poor design with much space wasted in corridors and lobbies and service areas. On the other hand, a low figure might mean a building composed only of classrooms with perhaps a cubicle for the principal. As a measure of value received for money spent, cost per classroom is relatively meaningless.

In an attempt to clarify unit cost measures, various alternatives have been proposed which would show how much usable educational space is provided on a per pupil basis. But definitions are not easy. When does an extra wide corridor become a supplementary classroom, or how is a locker room classified? If definitions could be agreed upon, then a comparison of educational space to total area would provide one way of looking at design efficiency.

All of the many cost elements in a school must be considered in order to *compare schools and their costs* properly.

These elements are primarily determined by the school board and the school administration:

- The immediate number of pupils who will occupy the school.
- The size of the classes.
- The size of the classrooms.
- What auxiliary spaces, such as auditorium, gymnasium, cafeteria, library, and music rooms, are provided and the size of each (they may be oversized for present needs if future expansion is planned).

Those who select the site have some control over these costs:

- The cost of the land.
- The cost of developing the land.
- Additional building costs which result from the peculiarities of the land.

The architect is largely responsible for these elements:

- The building layout and the space it produces.
- The ceiling heights (which may be controlled by state code).
- The type, size, and arrangement of windows and skylights.
- The exterior design.
- The kind of interior partitions and finishes.
- The type of floors.
- The amount and quality of interior cabinet work.

The mechanical engineer, working with the architect, is largely responsible for these elements to be compared:

- The arrangement of plumbing (there may be a code).
- The type of heating.
- The ventilation system (codes may control this, too).
- The type of artificial light and how much is provided (codes also).

Here are some general items for which no one is directly responsible but which must be considered in comparing schools and their costs:

- The year in which the schools were built and the influence of different building cost levels.
- The levels of local wage rates in the towns.
- The climate, which will affect over-all size and mechanical costs.

If a reasonable comparison of two schools and their costs is wanted, it is possible to make one. It requires considerable effort and some knowledge of costs to do it. Here is an example of how an actual cost comparison might look.

The school board in Town A was severely criticized because one of its recent elementary schools had cost $1,400 per pupil and $20.09 per square foot, whereas Town B, not far away, had built a school three years earlier for $657 per pupil and $13.11 per square foot.

An analysis of the schools and their costs would look like this:

Table VIII shows the step by step process which should be followed to account for the difference in cost between the two schools, by allowing for the difference between the physical characteristics of the schools, the difference in cost levels at the respective dates of construction, and the differences in the wage rates in the town.

Tables IX, X, and XI list the differences between the schools with price estimates for these differences.

This method of analysis helps to clarify the reasons for the differences in cost between the two schools. It is true that School A cost twice as much per pupil and 50 per cent more per square foot than School B. But after allowing for the *cost* of the *differences* in the schools it becomes evident that the cost per pupil and cost per square foot are much less disparate.

Our purpose here is to illustrate a method of comparison which is available to those who wish to compare *schools* and their costs. Whether the added items in School A, or their omission in School B, are justified, would find varying opinions among school boards, school administrators, architects, school children, and taxpayers. These are factors about which reasonable people can and will differ. Such an analysis makes it possible to discuss specific items of difference between the schools and their costs. The *value* of the differences can now be debated. Some of these values are real and tangible and others will remain forever matters of personal opinion.

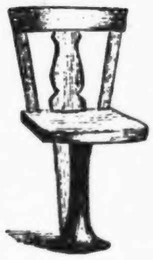


TABLE **VIII**

	TOWN A	TOWN B
	640 pupils	350 pupils
	44,600 sq. ft.	17,548 sq. ft.
	Built, 1957	Built, 1954

	Dollar Cost		*Cost per Pupil*		*Cost per sq. ft.*	
	TOWN A	TOWN B	TOWN A	TOWN B	TOWN A	TOWN B
Total Cost without Land	896,000	230,000	1,400	657	20.09	13.11
Less Fees	40,000	11,000	62	31	.90	.63
	856,000	219,000	1,338	626	19.19	12.48
Less Equipment	36,000	12,000	56	34	.81	.68
	820,000	207,000	1,282	592	18.38	11.80
Less Site Development	72,000	20,000	112	57	1.61	1.14
	748,000	187,000	1,170	535	16.77	10.66
Less Cost of Added Features (Table IX)	85,600		133		1.92	
	662,400	187,000	1,037	535	14.85	10.66
Less Cost of Lower Maintenance Items	33,500		52		.75	
	628,900	187,000	985	535	14.10	10.66
Less 10% Price Rise (3 yrs.)	62,890		98		1.41	
	566,010	187,000	887	535	12.69	10.66
Less Allowance for Wage Differential	27,672		43		.62	
	538,338	187,000	844	535	12.07	10.66
Less Adjusted Cost of Added Rooms	125,166		196			
	413,172	187,000	648	535	12.07	10.66

TABLE IX *Additional Features in School A, Which Added $85,600 to the Cost*

Feature	*School A*	*School B*
Steel joists	Concealed	Exposed
Basketball baskets	Six	None
Unloading canopy	Included	None
Intercom	Included	None
Controlled clock system	Included	None
Wardrobes	Closed-ventilated	Open-hanging
Cubicles and storage facilities	Included	None
Book storage	Adequate	Limited
File and paper storage	Adequate	Limited
Toilet facilities	Adequate	Limited
Ventilation	Adequate	Limited
Fire extinguisher	Recessed	Face-mounted
Individual classroom exits	Included	None
Plastic roof bubbles	Included	None
Plastered walls	Included	None
Flood lighting	Included	None
Decorative lighting—entrance corridor	Included	None
Radiant heat in kindergarten floor	Included	None
Recessed display panels and cases	Included	None

TABLE X *Money Spent in School A to Get Lower Maintenance*

Facility	*School A*	*School B*	*Added cost to school A*
Roof deck	Composition (*fireproof*)	Wood (*nonfireproof*)	$11,000
Lighting	Fluorescent	Incandescent	12,000
Dishwasher	Included	None	2,000
Electric service	Underground	Overhead	5,000
Radiant perimeter heating	Included	None	3,500
TOTAL			$33,500

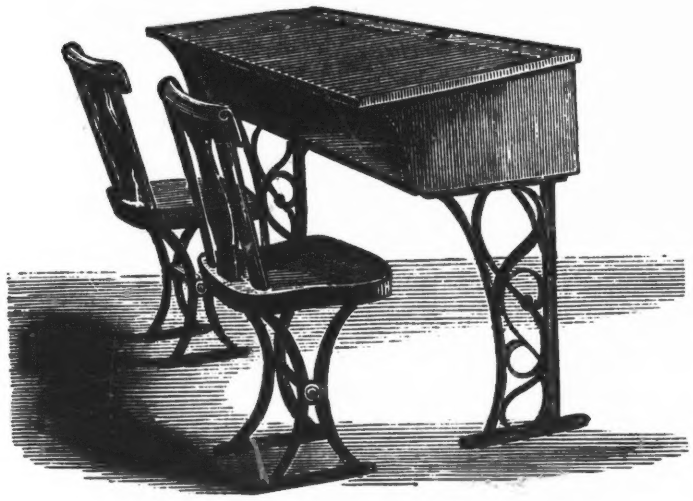


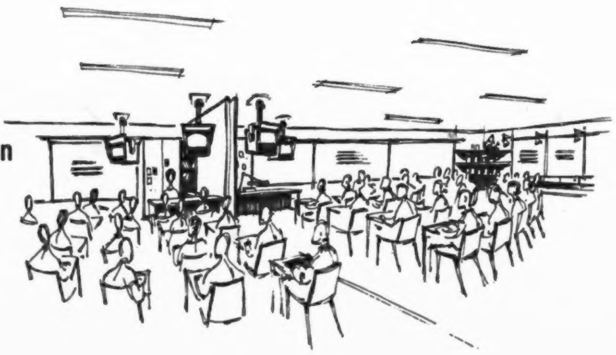
TABLE XI *Added Room Facilities Provided in School A*

Additional Facilities	*Area (sq. ft.)*
Multi-teaching rooms	1,800
Auditorium-gymnasium	5,220
Library	1,000
Larger classrooms	1,630
Principal's office	340
Remedial rooms	381
TOTAL	10,371

21 School Building

Some of the things contributing to the quality and cost of a school are:

Libraries



Television

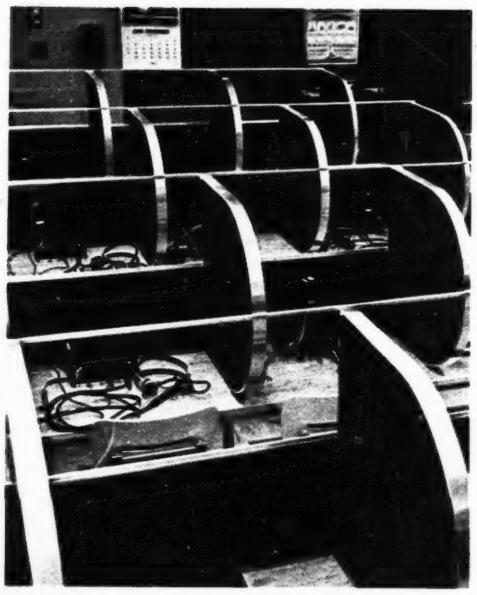
Vocational Shops

- *Careful educational planning is as important to real economy as careful architectural planning. Enough time for educational and architectural planning will save money.*
- *Selecting the best architect for your project is as important as any decision you will make in the building project. The best is no more expensive than the worst.*
- *Get professional advice before you buy the site. A cheap one may cost more to develop and may push building costs up.*
- *Don't waste space—every square foot of building costs money. Be sure you need it.*
- *Corridors, boiler rooms, and other non-instructional areas don't do much for education. Cut down on waste here.*
- *Use out of doors areas where you can—it costs less than building.*
- *Exterior walls are expensive—a short, simple perimeter will save money.*
- *Simplicity of detailing—the process of putting the building together—will contribute to both economy and quality.*
- *Use repetitive modular building elements wherever possible for economy in construction.*
- *Don't waste materials or use them unwisely—substantial economies are available through careful selection of building materials.*
- *Building with movable partitions will cost more initially, but may save future costs and keep the school from becoming obsolete.*

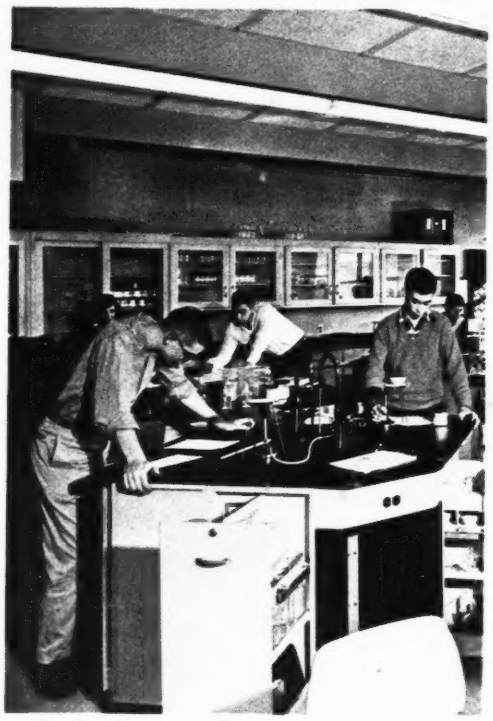
Economies

- *Intelligent multiple use of space offers real economy. Corridors, cafeterias, auditoriums, and classrooms can all serve double duty.*
- *The use of operable walls—which can be moved to combine or subdivide space—offers both initial economy in building and freedom in program.*
- *Foundations should be designed for imposed loads, not according to arbitrary practice.*
- *Be sure your architect is concerned with your acoustical problems before you build. Treating the problems later is expensive.*
- *The quality of light is as important—or more important—than the quantity, particularly above 30 footcandles. Consider special lights for special tasks rather than raising lighting intensity throughout the school.*
- *Watch out for overdesign in the heating system. It will cost more initially and more to operate if it is overdesigned.*
- *Consult your insurance agent during design. Make sure you won't have to pay an excessive amount for fire insurance.*
- *Use bidding alternates in moderation—but use them, particularly to test the economies of new building methods or materials.*
- *Don't confuse cheapness with economy.*
- *Remember that the purpose of everything that goes into the schoolhouse is to advance the educational program. True economy is achieved where the building supports the educational program to the highest degree.*

Physical Education

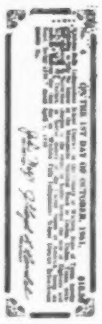


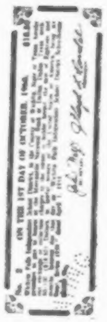
Language Laboratories

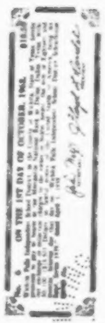


Science Laboratories

MONEY

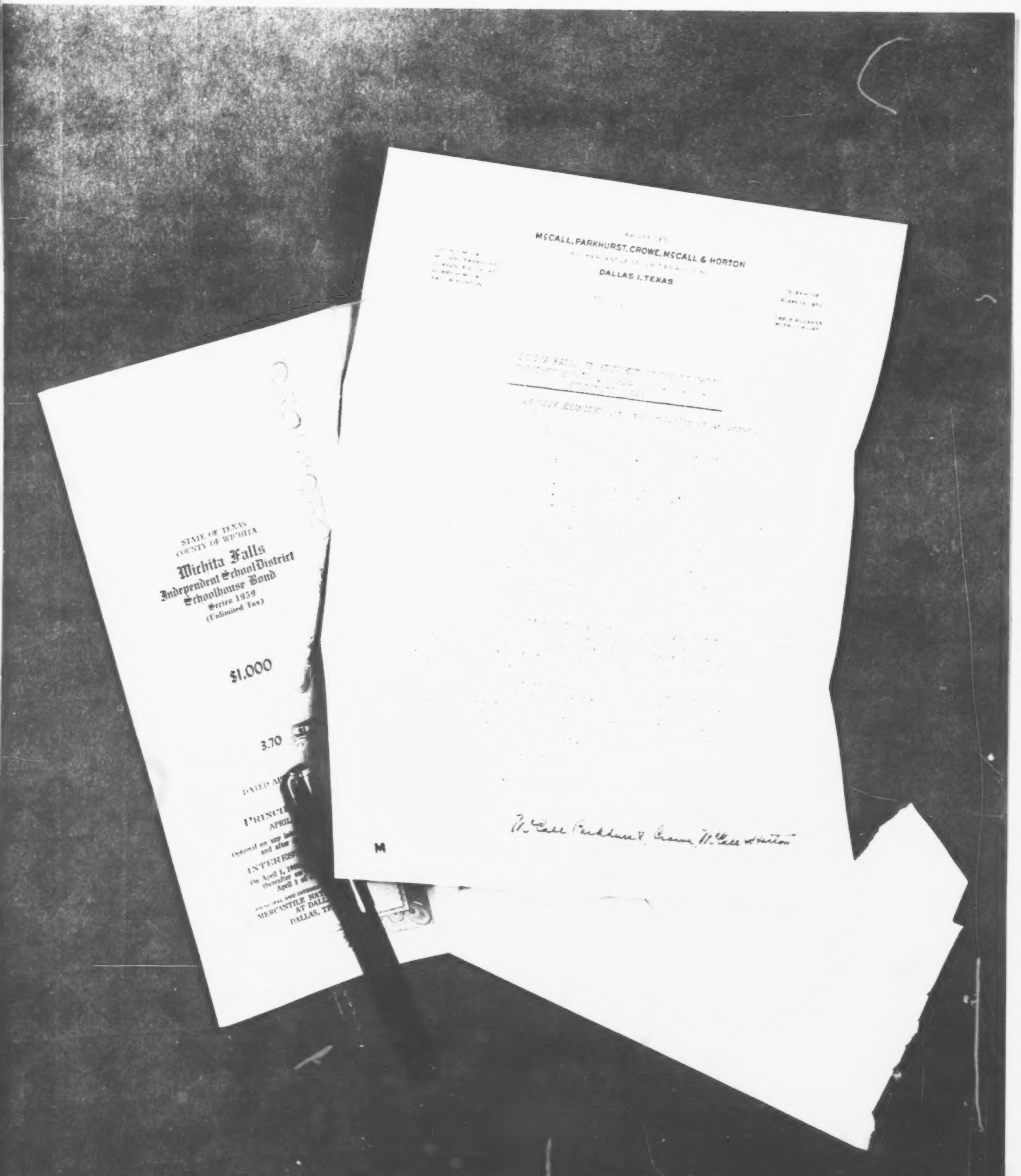






At an interest rate of 4 per cent, it costs over $1,650,000 to retire a million dollar bond issue in 30 years. A 1 per cent advance in the rate of interest would add another $160,000 to the cost. Borrowing adds substantially to the total price of a school building. The alternative to borrowing, of course, is to put all construction on a pay-as-you-go basis or to have built up reserve funds which can be drawn on for just such purposes. But few school districts (and few individuals buying a home) are either willing or able to pay for a building outright. Since school districts often are already under the shadow of past debts, to change to a pay-as-you-go plan tends to place an unduly heavy burden on today's taxpayer. Yet, pay-as-you-go is a prudent policy and can be used with discretion to meet part of capital outlay expenses. Such items as site acquisition, site development, minor additions, and renovations are among those which can often be met by expenditures from current funds.

The pay-as-you-go system is rarely feasible. The use of reserve funds is not often the answer either. Theoretically at least, the acquisition of reserves during periods of little or no construction and the use of these funds, either exclusively or in conjunction with long-term borrowing, enables a local school district to spread out the cost of capital outlay programs more evenly. Not only is the local tax rate less subject to fluctuations and instability, but the interest cost is also reduced. Historically, however, reserve funds have suffered from mismanagement, from diversion to other uses, and from the argument that the taxpayer himself could earn more on his money than the interest which the school district is able to secure. Moreover, school boards usually meet taxpayer resistance when they attempt to levy taxes for indeterminate future needs.



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STATE OF TEXAS
COUNTY OF WICHITA

Wichita Falls
Independent School District
Schoolhouse Bond
Series 1959
(Unlimited Tax)

$1,000

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As for states, the pressure on their finances is usually too great to set up construction reserve funds of hundreds of millions of dollars for payment to local districts as future building needs may require. In fact, the trend is for state legislatures to tap existing reserve funds to put public works programs into action. Reserve funds are consequently disliked by the financial community unless the funds are free of a public body or public control and are in the hands of a trustee. Such funds do not represent the same kind of tangible security as school bonds.

For almost all school districts borrowing is necessary. And borrowing usually means the issuance of long-term obligations. These long-term loans in the form of bonds may be for 10, 20, 30, and even 40 years. Short-term loans for a period of 1 to 5 years or less are sometimes used as a temporary measure to tide a district over to a better marketing period. These temporary loans must be paid off with the proceeds of long-term bond issues. Many states have not yet passed legislation permitting such short-term financing of school construction.

When a school district wants to borrow money, it is competing with all other classes of borrowers, including financial institutions, private corporations, and other governmental bodies. In order to get the best terms, i.e., the lowest interest, a school district must make its offering as appealing as it can to as many classes of potential investors as possible. This is one of the reasons why the serial bond is the type of bond used by school districts. A serial school bond issue consists of bonds, usually of $1,000 denomination, so scheduled that some bonds fall due each year for the length of the issue, the number depending on the repayment schedule. The serial bond attracts a greater variety of customers. It is of interest to those preferring either 1–10 year bonds or 10–20 year bonds, as well as to those who wish to invest their money for periods from 20 to 30 years. Commercial banks, which represent the largest single investors in school issues (holding some 30 per cent) and which head many of the bidding syndicates, prefer to invest their own money in the short 1 to 10 year maturities. Savings banks, on the other hand, would rather have longer serial bonds, as would casualty and fire insurance companies. Pension funds and certain insurance companies frequently prefer 30 year obligations.

MARKETABILITY OF SCHOOL BONDS

"Let us all . . . live within our means even if we have to borrow the money to do it with."

Artemus Ward
Natural History

School bonds represent a substantial portion—close to one-third—of all municipal bonds being offered in the money market. The price which investment bankers are willing to pay for them is determined by a variety of factors, including the credit of the district, the demand for school bonds of similar quality originating in the same state, and the current condition of the money market at the time the bonds are issued. School districts can secure better bids, that is, lower interest rates, if they understand the preferences and requirements of people in the securities business and, so far as statutes and regulations permit and the needs of the school district allow, design their issues to fit these requirements.

Although their tax-free income gives school bonds a particular appeal to certain groups of investors, these bonds still lack the highest degree of marketability because the bond market tends to favor obligations backed by the credit of the state. The most important factor in marketability is the *credit rating* which a bond carries. These ratings are prepared by firms which specialize in studying and evaluating the relative investment quality of all kinds of bonds, those of private corporations as well as those of public agencies. The rating of securities takes into account such factors as the present outstanding debt of the district, its general economic level and social conditions, and the cost of its current operations. Moody's Investors Service, on a rating scale which starts with Aaa, generally rates school bonds Aa, A, and Baa. School bonds rated Aa and A generally command a lower interest rate. Standard and Poor's Corporation, another major rating service, applies quality symbols which for school bonds range usually from A1 and A to B1+.

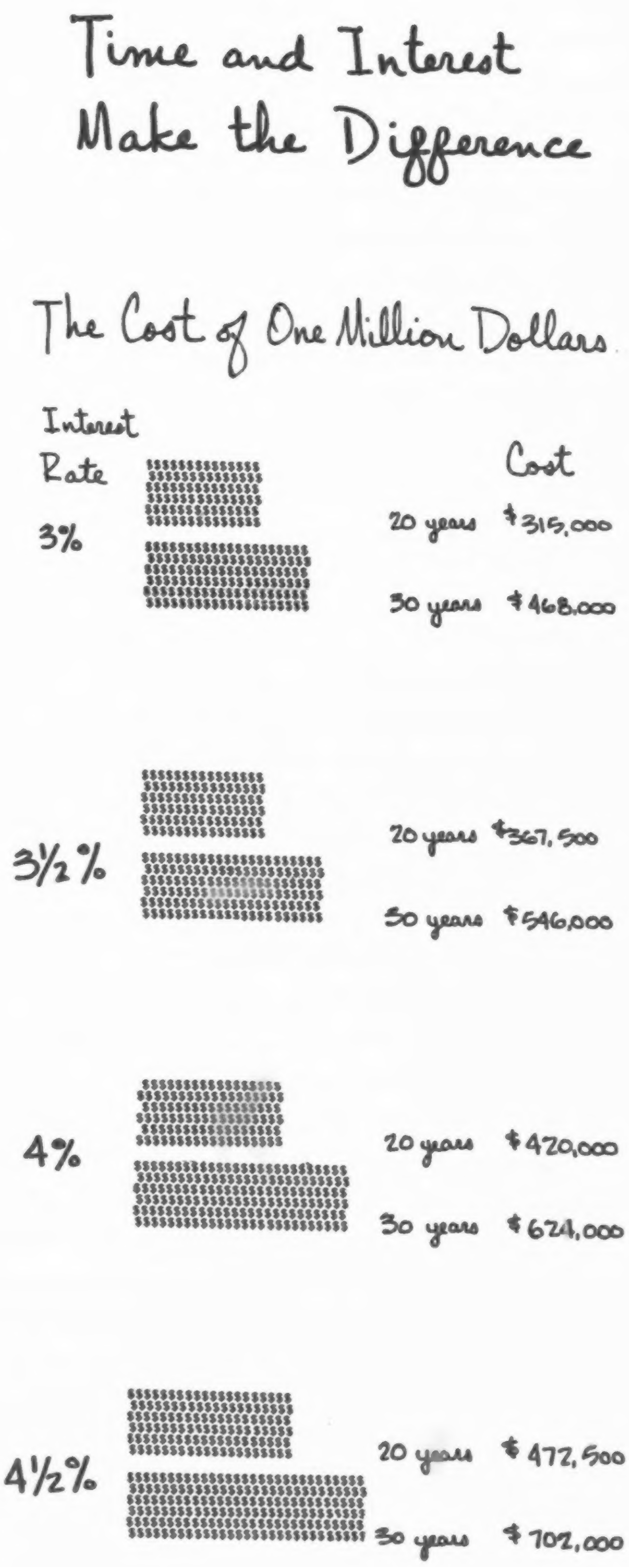
Marketability of bonds is often increased as school district boundaries become larger or if the districts are coterminous with cities or communities of high repute. Programs for district consolidations or plans which provide for the financial strengthening of local school districts will often raise credit ratings and help insure lower interest rates.

Marketability can also be strengthened by direct state action. It is for this reason that some states, such as Florida, issue bonds on behalf of the counties. On January 27, 1958, the Florida State Board of Education offered a group of bond issues which totaled $7,855,000. Each bond issue was stated to be "for and on behalf of the county" with 11 counties participating in the group of issues to be sold. Each of the issues was to be secured by a "first, prior, and paramount lien on state motor vehicle license taxes . . ." In this example, the state, while not using its own credit, agreed to the use of certain state funds for the payment of the bonds offered on behalf of each participating county.

New York State now requires the State Comptroller to withhold from State aid due a local school district such funds as may be necessary to pay both the principal and the interest on any default by the district. As soon as the announcement of this legislation was distributed in April, 1959, there was strong positive response nationally by prominent investment banking houses, both in their releases and in their advice to investors. This is credited with having helped the stability of New York school bonds in May and June of 1959 during a weak bond market. In effect, it resulted in their upgrading.

Any way in which the state can be brought into the picture will improve the rating of the thousands upon thousands of relatively obscure school districts. And at 4 per cent interest, a favorable change in rating can mean an interest saving of ⅕ to ¼ of 1 per cent. On one million dollars over 30 years, this could mean a saving of $40,000 to the taxpayers. Consequently, one key to economy in capital financing is raising the rating of a school district's obligations.

Another central problem in the marketability of school bond issues is the narrowness of the demand for them, coming as it does largely from investors in the state or region in which the bond issues originate. Unless the individual school district carries a name well known and respected nationally, it is a virtual stranger to the bond market outside its own state. This is partly because of the sheer number of local school districts in the United States and partly because of the complex (and confusing) names carried by some consolidated districts. The



On the basis of equal annual payments of principal, except that the thirty year issue matures $33,000 each year for the first twenty years, and $34,000 each year for the final ten years.

smaller the demand, the higher will be the interest rate bid by the investment bank or syndicate, to enable it to sell the bonds with a reasonable profit.

In order to broaden the school bond market, New Jersey recently published a report for investors entitled "New Jersey Schools—Invest for Your Future Security." Similar publicity by other states can help acquaint the investment field with the desirability of their school bonds.

A school district is also aided in the sale of its bonds by the use of nationally recognized bond counsel. Bond law and bond proceedings are complex and unique, and the preparation of bond issues requires the use of lawyers specially trained in the skills of this field. Investment bankers and commercial bankers heading the syndicates, which bid on school district bond issues and all other types of public securities, require that the proceedings be prepared by a firm of nationally recognized municipal bond counsel and that the counsel's opinion approving the bond issue be delivered to the successful bidder. A refusal by such counsel to deliver an unqualified legal opinion, due to irregularities in the bond proceedings, bond election, or bond law, will usually nullify the sale. In a number of school districts the local attorney for the district is employed at substantial expense to aid in the preparation of the bond proceedings. This is often an unnecessary expenditure since the local attorney must normally depend upon expert bond counsel for his forms and often for the actual drafting of the papers.

Another aid in the sale of a district's bonds at a satisfactory interest rate is the use of a prospectus. Knowledge of relative economic and social conditions is fundamental to an investment syndicate's evaluation of a district's bonds. Type of community, kind of industry present, population data, assessed valuation, total tax levy, tax rate, tax collection record, total debt statement, and amount of state aid are all among the factors which should be analyzed in detail. Since the sole security behind the school district bond is the taxing power of the district, property valuation data on all private property within its limits should be presented in detail. If there is a particularly large taxpayer, such as a public utility or an industrial plant, its assessed valuation and a description of its property as a taxable entity should be given. It is

A prospectus to advertise the community's assets should be attractive and informative in order to awaken investor interest.

AREA FACTS
Transportation
Recreation
RECENT DEVELOPMENTS
Progress
DEVELOPMENT EFFORT
site m

helpful also to present a judicious estimate of the future need for additional schools. If no additional classrooms will be required for many years, that fact is of vital importance.

The prospectus should also present the debt of other public bodies, including water districts, sewer districts, and fire districts, which overlap the school district or lie within its borders. It should include complete details on the bonds presently being offered, including the maturity schedule, the place of payment, and provisions for redemption before maturity.

The mistaken idea that a simple one-page circular is adequate needs to be abandoned. The analytical investor in municipal bonds knows little of the economic and financial soundness of each individual district. The prospectus should awaken his interest in the bonds of a public body previously unknown to him and should provide him with sound factual material which will prove the bonds are a good investment.

THE TIMING OF ISSUES

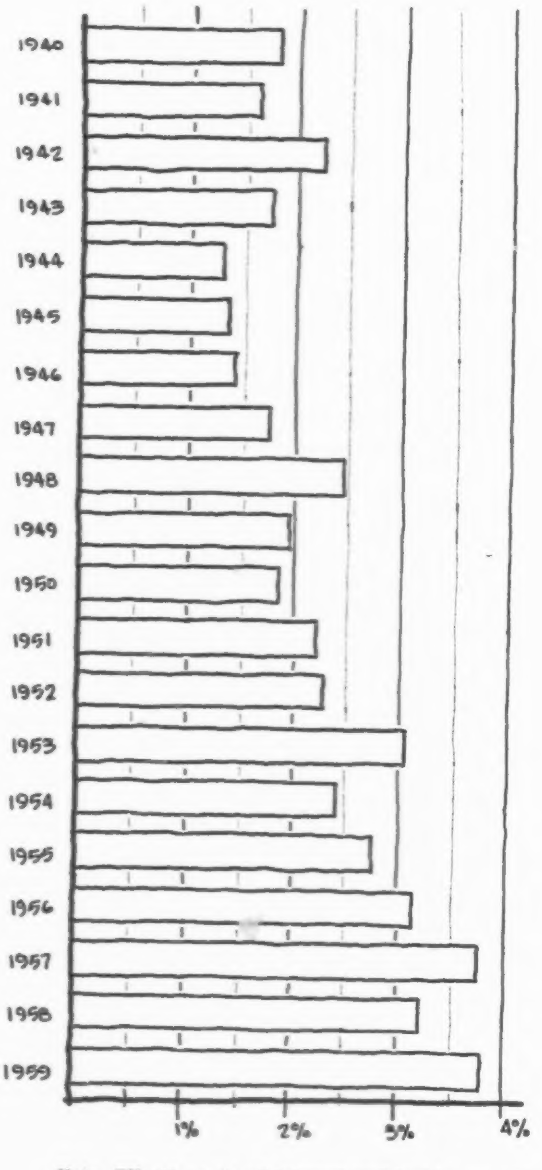
The interest cost of a bond issue depends on its timing as well as on its marketability.

In periods of temporary stress it may be advisable to delay offering a bond issue and to wait for a better market. If many school issues are being offered for sale at the same time, it may be wise to time an offering so it is not made in the same day or week as other large ones. There have been recent periods when there were no offerings for two or more weeks, and then many offerings from a single state were made in one day. Since most issues are bid by the same syndicates and it is difficult for syndicates to tie up large funds in more than three or four issues, proper timing is particularly important, especially for large issues. Recently, for example, a single issue for $11,270,000 was offered and sold by one school district alone. Such timing, of course, requires a general knowledge of the level of activity of the bond market.

The attempt to take advantage of money market conditions in order to secure the best possible interest rates has led some districts to rely heavily on short-term loans. While short-term issues have been used as a mechanism to wait for more preferred rates, this is a mechanism with built-in problems, and it should be used with caution. One reason for this is that after it is used once, such short-term financing usually cannot be repeated. But more important is that in a period of rising interest rates on bonds the delayed sale may cost the district more in the long run. Many school districts which tried a few years ago to outguess the money market now need to refund their short-term obligations at a time when long-term interest rates are hitting new highs.

A further danger in the "wait and see" method of short-term financing is that in trying to outride a period of high money rates school districts issue a large amount of short-term debt. Too much short-term debt which must be refinanced into long-term obligations at any one time reduces the favorable position of a district. A number of school districts which have used short-term loans are now facing serious refinancing problems.

Annual Interest Rate of New York State School Bonds



Note: Effective rate of interest weighed by amount of bond issue.
Source: New York State Department of Audit and Control.

WHAT IF ALL THE BIDS ARE HIGH?

If competent advice suggests that the bid or bids on a school district's long-term issues appear to be high, then it is sound policy to reject the bids and to reoffer the bonds at another sale or to finance temporarily if the statutes permit. It is necessary to analyze those factors which were responsible for the unfavorable response and to take positive steps to correct them. Bids may be high because of lack of competition. This is particularly true of rural districts where only one bid may have been received. In such a case it is probably wise to reject the bid. Indeed, it can be stated as a general proposition that whenever possible a district should never sell its bonds if it receives only one bid. Unless it has other bids for comparison, it is at a loss to know whether or not to accept the offer. If not enough parties have indicated interest in the bonds, better data and wider advertising in financial journals may be called for. Or it may be that the maturities were set improperly for the immediate needs of the market. A district may be offering 15-year serial bonds when issues with longer maturities are in demand. There are fluctuating conditions in the money market, and a district needs to know them in order to tailor its offering to the best advantage. Another possibility is that the issue may be too large. If so, it might be advantageous to offer it in two stages.

So that school districts may be able to avail themselves of the most promising methods of long-term financing, several states have begun to establish financial advisory services. Such services can render important help in improving marketing procedures for school bond issues. They hold a promise of yielding substantial economies to the local taxpayer.

LIMITATIONS ON SCHOOL DISTRICT BORROWING AND ALTERNATIVE SOLUTIONS

Almost all states impose some debt limitations based on property valuations. These are usually written into the state constitution, and range from a 2 per cent limit in Indiana and Kentucky to 10 per cent in Missouri and 20 per cent in Florida.

Ratios between assessed valuation and the actual market value of property frequently differ strikingly between school districts—all the way from 10 per cent to 90 per cent or more. Therefore, the very same debt limitation may permit a debt for one school district in an amount many times the size of that which another district with the same estimated total market value of property is allowed to incur. In some cases, the law requires that all property be assessed at true and fair market value, and there are some communities where this is done, but they are a very small minority. Wisconsin and New York require that debt limitations be based on equalized full valuation. Other states should move in the same direction.

One method sometimes used when debt limitations are excessively restrictive is that of permitting a district to borrow "outside the debt limit." Usually this needs to be done by state legislative action or on authority of a state emergency finance commission. Such devices are subterfuges at best, since the financial community is primarily concerned with the district's rating rather than with technical statutory limitations.

The problem of constitutional debt limitation has led to the use of various devices by which the local school district tries to circumvent the borrowing restrictions under which it must operate. One of the first of these to be used successfully was the Kentucky leaseback plan. Under this arrangement a private school building corporation is created for the benefit of the local school district. The private corporation purchases sites, erects buildings, leases them to the district, collects rents for their use, and uses the rents to pay back the principal and interest on its bonds. When the indebtedness has been retired, the nonprofit corporation deeds the school building to the district. The corporation's project is financed through the sale of bonds, and, since the debt is not a debt of the school district, it is not subject to the local debt limits. The fly in this ointment, however, is that the corporation does not have a top credit rating. It is, therefore, expensive for the local district to use it. But the district does use it because it has no choice. Its own low debt limit requires such a plan.

The building corporation has a number of other weaknesses. The most important is that its securities are not local government obligations and, therefore, are no stronger than the willingness of the local school district to continue its lease-rental payments. The bonds thus have limited marketability, and this makes them more expensive. This is an example of how a low debt limit structure can actually add to the cost of schools. Nevertheless, the Kentucky plan has been widely and successfully used in that state for the past 30 years. It has also been used extensively in Indiana.

The private building corporation is the direct predecessor of the school building authority. This type of structure has been most fully developed in Pennsylvania, both on the state level and on the local level. The Pennsylvania constitution limits the amount of money that can be borrowed by a school district to 7 per cent of the assessed valuation of the taxable real property. It is estimated that the State average for real estate assessments, exclusive of the large cities, is approximately one-third of true valuation. This valuation and the 7 per cent debt limit make borrowing problems for many Pennsylvania districts and have led to the creation of school authorities.

The Pennsylvania State Public School Building Authority combines the lease-rental plan of the corporation with State aid payments to the local school district. The corporation pays off the bonds from the proceeds of the lease-rentals it has collected from the school districts. Although the bonds do not pledge the credit or the taxing power of the Commonwealth, they are tied to State aid payments, which gives them a better rating than those of the private corporation. If a school district defaults on its payments to the State Authority, the State is authorized to withhold from the district an amount of rental aid equal to the default and to make such payment directly to the Authority.

Several other types of school authorities have been developed in

A CASE STUDY OF FISCAL FOLLY

TIME:	*1908*
PLACE:	*A New York suburb*
FOR:	*Purchase of site and construction of an elementary school*
COST:	$70,000
BONDING:	*Noncallable bonds were issued in 1908, principal payable beginning 1913 to and including 1982 at $1,000 per year maturing in 1982.*

The Cost of Principal and Interest through 1982:	$181,560
The School Cost:	$ 70,000
The Money Will Have Cost:	$111,560

THE MORAL: *Money Costs Money*

Pennsylvania which operate on a local rather than on a state level. These may be independent local authorities for individual school districts, or they may be authorities set up as *joint* school authorities to build projects for several school districts. Joint school boards are created by voluntary resolutions of the individual school boards who wish to join together. The joint district through its joint board creates a local joint school authority. Many authorities in Pennsylvania are now of this type, and this plan has become one of the strongest motivating forces for school district consolidation.

While the Pennsylvania local authority system of financing school building construction has been both praised and damned by financial experts, the consensus is that it represents an awkward financing device. This view holds that, while it is feasible and workable, it is expensive in terms of interest costs and does not furnish any evidence of saving over conventional school district financing; its higher interest costs are directly transferred to both the state and the local property owner who bears the real estate tax burden. The Pennsylvania local authority system is illustrative of the way restrictive conditions force legal inventions or adaptations which are not always efficient or economical.

In contrast to, or in conjunction with, the various devices designed to get around state imposed debt restrictions are the programs of direct state action.

STATE PROGRAMS FOR PUBLIC SCHOOL CONSTRUCTION

State Bond Issues for Loans California is the outstanding example of a state which has used its own bonding power to finance local school districts. Since 1949 it has issued bonds for school construction amounting to $615 million.

The provisions for repayment of a school district loan to the State of California are such that a district is not required to make any repayment to the State in a year when the district's total levy to meet prior bonded debt is 4 mills. However, if a 3-mill levy ($3.00 per $1,000 valuation) will meet prior bonded debt in that year, the district is required to repay the State an amount equal to a 1-mill levy.

State loans to school districts in California must be paid off in 30 years and any debt unpaid at the end of 30 years is automatically written off by the State. The district's annual repayment to the State is to meet both principal and interest on the State's loan to the district, but no interest payments on the loan are required after 25 years.

Maryland and Michigan also issue state bonds and then lend these funds to the local districts for their building projects. The Maryland plan, like that of California, began operation in 1949. The original authorization was for $50 million, and additional authorizations of $20 million and $75 million were made in 1953 and 1956. Maryland law requires that each school construction loan shall be repaid in full with interest and that a sufficient annual levy be made on the property within the county to retire the loan. The State Comptroller withholds, from the annual State aid payment due the county, an amount equal to the county's payment due on its loan. All the counties in Maryland have participated in the program, and it has been necessary to give the State additional bonding power from time to time, to enable it to continue this financial assistance.

In 1955 Michigan created a $100 million State loan fund for the payment of both interest and principal on school district bonds. The plan permits any school district needing construction funds, *when its tax rate becomes more than 13 mills for debt service in any year,* to apply to the State for a loan representing the difference between the amount the district would actually require to pay principal and interest in that year and the amount provided by a 13-mill tax rate. The peculiarity of the Michigan plan is that a district may apply at the time it issues its bonds *regardless* of its then current tax levy for bonded indebtedness. For example, a district may have only a 7-mill tax rate at the time its bonds are issued. But it makes application at the time of issuance, anticipating that in a future year it may have to push its rate up to 13 mills; and in any year in which its rate goes over 13 mills the State steps in to help. Almost all districts issuing bonds apply for State assistance even though very few of them need it at the time of issuance. This Michigan program represents a cheap "standby device," and as such has many desirable features.

Other State Funds for Loans Some states have revolving loan funds for aid to local districts. These funds are set up with monies from current revenues, special appropriations, or other sources exclusive of bond issues. Arkansas has such a fund from which it grants small loans, the maximum being $50,000 to any one district. Almost all the districts in the State have used the fund since its establishment 12 years ago. The same type of fund exists in North Carolina, where it is called the State Literary Fund, but the North Carolina fund has been used by very few school districts because of strict requirements and a low maximum limit on loans.

Virginia's loan fund, also known as the State Literary Fund, has been used by most of the districts which have let contracts for school construction since 1950. Loans up to 100 per cent of the cost of construction have been made with relatively low interest rates. Annual repayments on the principal are made over a period of 30 years. Under this arrangement more than $36 million was committed to school districts in the years between 1950 and 1957.

State Grants In addition to loans, state bonds have been issued to finance all or part of a program of direct state grants in a number of states, including South Carolina, Delaware, Vermont, and Washington. These states have used their general credit to borrow money for school purposes and have allocated the money to local school districts.

Another group of states has insisted that local school districts use their own borrowing capacity and issue their own bonds without the aid of state bond issues. These states, however, have been liberal in giving assistance to the districts to meet debt service payments on their bonds.

In Massachusetts, for example, annual appropriations are made from State general revenue to finance direct State grants for school construction. The grants may be used in two ways. The State may give funds directly to the district towards the cost of school construction. Or, on the other hand, if the bonded indebtedness exceeds more than 50 per cent of the cost of the project, the amount of the grant is divided by the number of years the indebtedness will remain outstanding, and the grant is paid in equal annual installments during the period in which the bonds are being retired. Connecticut has a somewhat similar program using State general funds.

Other Types of State Aid In 1958 New Jersey authorized a fund to be used to purchase a school district bond issue when a default is anticipated, or to pay interest on such bonds in the hands of outside holders so long as the district is unable to make such payments. Although this fund is relatively small, totaling only $18 million in 1958, it definitely has been a strengthening factor for marginal school district bonds of that State.

The New Jersey plan has certain advantages over that of Michigan. It is more flexible in that the State can move in at any time to bolster the bonds of a district (thereby protecting all its districts) by taking a weak issue out of the regular market. In comparison, Michigan requires stricter conformity to its eligibility regulations before a school district can qualify for aid, in that a district must qualify its bonds long in advance of the time when default troubles could arise.

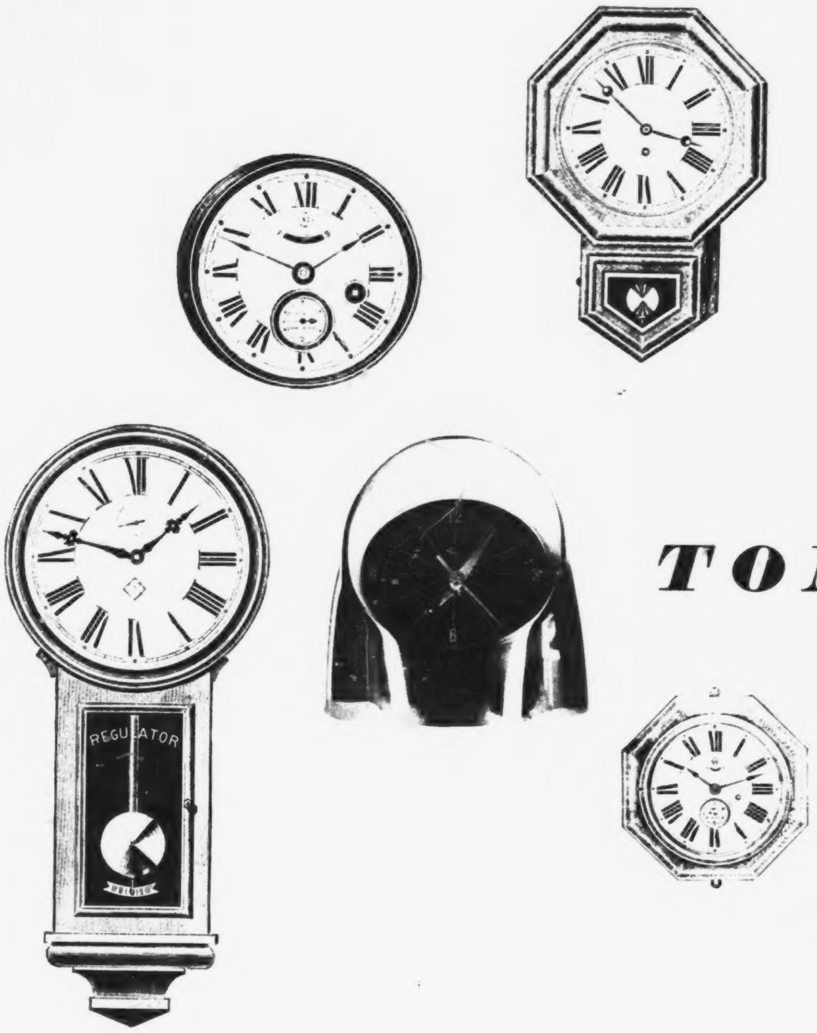
New York also has recently provided a new type of state aid program for school building bonds. This measure gives relief to certain school districts which are compelled to pay an excessive interest rate on their bonds. School districts are eligible for such aid if the rate of interest they must pay is more than ¼ of 1 per cent in excess of the average rate paid on similar bond maturities by those districts which sold bonds during the previous six months. Many districts which receive other types of school building aid are ineligible for excessive interest aid.

It is clear that the trend since 1945 has been toward further centralization of school district financing in the state capitals. One state after another has come forward with some plan to help local districts finance their bonds. These plans have ranged from help in meeting interest payments to the purchase of the bonds themselves to the taking of some type of loan contract obligation of the district in lieu of bonds. These plans may eventually result in more financing by states and state agencies and less financing by the local districts.

Does this mean that the voters and the local school board members will be satisfied with less control over spending? Will the traditional small school district bond issue become extinct? Probably not. Both the short- and the long-term outlook for school district bonds appear good. Debt service obligations of currently outstanding school bonds will be met with ease by most districts. Moreover, the high quality of these bonds will be recognized even more generally in future years as many states follow the lead of Michigan, New York, and others in making the investor aware that school bonds are among the finest investment media the market affords.

To Get The Most For Your Money

- *Advertise. Let the investment field know who you are by printing a prospectus. A knowledge of your assets and future growth helps to convince potential buyers that your community is a safe place to invest their money.*
- *If you're thinking of making a short-term loan to outride a high money market, unless you have a very clear crystal ball, think twice. The short-term issue can be a ghost that comes back to haunt you—it may carry you into a period of the highest interest rates ever.*
- *Gear your bonds to appeal to the broadest group of buyers. Serial bonds do this best—they attract both long- and short-term investors.*
- *Don't sell your bonds until you need the money. Schoolhouse construction is often a slow process. Let the architects complete the plans, let the bids be taken, let construction awards be made, before you sell your bonds. It can cost you a full year's additional interest if the bonds are outstanding a year too soon.*
- *Watch your timing. Don't put your bonds up for sale when the market is glutted. Wait for the day or week when there are few other school issues for buyers to choose from.*
- *Analyze the bids. If there aren't enough of them, or if they all seem too high, you might be wise to withdraw the issue, re-work it, and offer it for sale another time.*
- *Eliminate unnecessary legal costs. Since you will have to retain outside legal counsel who are specialists in the field of municipal bond law, there is no point in paying your local attorney an extra fee for the preparation of the bond proceedings. When the bond counselors are retained to render their opinion, they will prepare all the necessary papers without additional cost.*
- *Make certain your bank pays you the going rate of interest on the money you receive from the sale of the bonds—or invest the proceeds in short-term U. S. government securities. Much of your bond money may be in the bank for several years while the schoolhouse is being built. Make that money work for your district.*
- *Investigate your state's school construction aid program carefully so you can take advantage of all its benefits.*



TOMORROW

Prediction is risky business. Predict the obvious, such as that more schools will be needed for more children, and the reader's reaction is "this is where I came in." Predict the obscure, the uncertain, the far-distant, and the reader says, "If so, are you for it or against it?"

Yet there are changes making up in education, some clearly visible and visitable. Others are still in the talking stage but properly belong now among the things to consider when a schoolhouse is planned.

"Form ever follows function," said Louis H. Sullivan. Function is basic. From function flows the original form; thereafter the form permits the building to function or stands in the way. The building is shaped by the way we put buildings together—architecture—and by what its owners declare will be going on in it. Its spaces will be arranged as the occupants will be arranged. Its surfaces will be selected according to the purpose of the space: warehouse surfaces for the storage of things; shop-like surfaces for the making of things; satisfying and comfortable surfaces for the discussion of things. And over both form and surface tower considerations of economy and beauty.

Many a school being built today will be operating well into the twenty-first century. If tomorrow's school must accommodate tomorrow's methods and tomorrow's content of education, it behooves everyone who plans a school today to think about the probable shape of things to come—such as these:

3

SMALL SPACES WILL BE MULTIPLIABLE AT WILL AND AT ONCE

Central to the design of space for teaching and learning is how the persons involved, adults and children, are to be deployed. If the custom continues of arranging children in uniform class groups of 25 to 35 or more children to be taught by one teacher, unaided and alone, then the schoolhouse will continue typically to be a series of uniform classrooms, of equal-sized boxes, supplemented by such specialized large spaces as the standard gymnasium, whose dimensions are determined customarily by the requirements of basketball; an auditorium, which may stand idle for all but a few hours each week; a cafeteria, offering little other use than noontime feeding; and a library.

If, on the other hand, schools move toward arrangements of pupils and teachers that vary from the solitary teacher in her solitary classroom, the arrangement of spaces will vary accordingly. A number of school systems, chafing under the restriction of the conventional egg-crate arrangements of classrooms, row on row and layer on layer, have moved on to a clustering of four or more classrooms around a central space as a way of bringing better communication among teachers and, to children, a sense of community larger than the classroom but smaller than the school.

Today's clustering of classrooms is a half-step development toward the variety of space required when teachers become members of instructional teams and pupils are regrouped from time to time during the day according to the size of group most appropriate to the task at hand. To use an analogy from medicine, fewer teachers will be general practitioners, and more will be specialists. Thus also will return to teaching a zest for scholarship since each teacher on the team needs to know in depth—and have pride in knowing in depth—a particular field of knowledge.

Many schools are now being designed to provide instructional spaces of varying size—from individual study spaces to the small, round-the-table, seminar space, to lecture-discussion rooms that double, triple, or even quadruple the standard classroom. But the desire now expressed by a number of schools to achieve malleable space that can be shaped at once and at will must await the development of a retractable partition which will give acoustical privacy. It seems likely that such a partition will soon be available, since only its cost remains unsolved.

The quest for immediate flexibility has taken many forms. The Belaire Elementary School in San Angelo, Texas, a circular school of eight classrooms, separates its rooms by retractable partitions. Several schools now on the drawing boards, or under construction, are specifying the retractable partitions—e.g., the Chicago University Laboratory High School, the North Chicago Teachers College of the Chicago Board of Education, the Newton South High School, Newton, Massachusetts, and the Dundee School in Greenwich, Connecticut, which is designed for team teaching. Schools of loft construction, such as the Hillsdale and the Mills High Schools near San Francisco and Clare High School, Clare, Michigan, provide flexibility not at once but within hours. Indeed, most schools being planned today are careful to make sure that some interior spaces are not frozen, even if only to the extent of separating classrooms by nonbearing cinder-block or other cheaply destructible walls, however rare their actual removal.

LARGE SPACES WILL BE DIVISIBLE AT WILL AND AT ONCE

Immediate divisibility of large spaces through the use of folding doors has, of course, been standard practice for years in gymnasiums. Because relatively low levels of acoustical privacy can be tolerated in a gymnasium, these doors have worked with reasonable success. But for most other spaces, particularly the academic, the folding or otherwise movable partition, though tried many times through the years, has usually proved ineffectual in stopping the intrusion of intelligible sound in areas that require acoustical privacy. When a simple, removable barrier offering acoustical separation becomes available at reasonable cost, the principle of mutable space will find ready adoption for academic spaces, thereby increasing the freedom to group children at will and to diminish the spaces that otherwise, but now necessarily, lie idle in many schools. Both education and economy will thus be served.

Hotels have long recognized the need for securing high multiple use of space in ballroom and banquet areas. Large business concerns which conduct meetings of varying sizes are providing divisible space. A number of colleges are experimenting with divisible studio-auditoriums. In Boulder City, Nevada, a high school auditorium is about to be constructed to provide three lecture-discussion spaces at once by drawing partitions across a 600-pupil auditorium. The Superintendent of Schools of Boulder City estimates that this divisible auditorium in a large high school will reduce by five classrooms the total amount of academic space that would otherwise have to be constructed. If his calculations are accurate it is clear that though divisibility costs more than nondivisibility, the over-all effect is to diminish the cost, to increase utilization, and to accommodate more sensitively the kind of academic arrangement of teacher and pupil, collegiate in principle, toward which many schools are moving in the press for academic achievement. As James Marston Fitch wrote in American Building: "Deeply ingrained prejudices in favor of maximum permanence in structure tend to obscure the fact that maximum performance is what we should demand of our buildings today."

SPACE WILL BE ADDED AND SUBTRACTED AT WILL

Most large school systems can predict with reasonable accuracy the total number of children who will be enrolled in the school system for a few years ahead. But prediction of the ebb and flow of enrollments in individual schools defies all available arithmetic. To illustrate: last year San Diego built a new high school for 1,500 students. Factors visible now but not then will cause the building to overflow next year by a dozen classrooms. Chicago has a 1,200 pupil school with an annual turnover of 100 per cent in enrollment.

One way to provide schools at once for overflowing districts is to dispatch mobile classrooms and related facilities. Los Angeles, for example, has 3,300 transportable classrooms, and moves about 500 around the city each year. In San Diego, approximately 23 per cent of the school population is housed in transportable schools. Houston, Texas, uses a thousand transportable classrooms; Rochester, New York, and Toronto, Canada,—indeed, a host of communities—use mobile classrooms to rush space to overflowing schools and to recapture their equity when the rush is over.

The trend toward transportable schools has been hampered by the common practice of making them substandard, makeshift arrangements unworthy of careful design, good construction, and continued maintenance. In many communities the transportable school has inherited the disrespect of the World War I shed-like "portable" that still blemishes the backyards of schools in our big cities.

Yet there will be developed a mobile, probably demountable, school that will be good. It will provide for children and teachers an environment at least as good as the permanent school. And it will offer to educational management the ability to provide space on short notice and later to recover that space for deployment elsewhere as unpredictable needs arise. Some rapidly growing school systems have set a proportion of one-fourth to one-fifth of all space to be mobile.

To avoid unnecessary building as the waves of enrollment pass through a school system, expect the junior high school to become the flexible linkage between elementary school and high school, varying in grades contained according to the flow of enrollments in the whole system—at times housing grades 7–9, at others, 5–8, 6–8, 7–8, and possibly other combinations. Even the name may gradually change to "middle school," and its purpose and the grades contained may be exactly that—the school that is midway between the elementary school and the senior high school.

SOME SCHOOLS WILL BE CONVERTIBLE AND SHARED

Communities, like families, mature—and at different rates. Some communities in America have clearly matured. No more land is available for new homes. Old homes are giving way to encroaching business, industry, and commerce. Coming down the street toward the school are the neon signs, the automobile sales lot, the beer joints, the light manufacturing, the decaying residences. Left by the side of the road is the schoolhouse, half empty, ill-maintained, and obsolete, adding its gloom to the general depression, unable by its unchangeability to accommodate itself to the engulfing tide. There it sits, no longer good for children, no longer good for anything. And eventually it is abandoned, sold for the value of the land less the cost of demolishing the building.

Almost every city, even the satellite suburbs, has schools like this. Not just the big old cities need worry about this; the big new suburbs should think about this matter.

The life and death of areas in a city are fast reaching predictability. The school board, superintendent, and architect who plan each school for an unchanging society saddle us with a continuation of the errors of our forefathers. Consider with every school whether it should be designed for the ages or just for a time until it must be something else—a showroom for the automotive trade, a place of manufacture, an office building, a settlement house? Will a school always be needed here? If not, plan now, for later is too late. Design it to be good as a school in its early years, but convertible with grace to other use, to business, to commerce, to housing, or to whatever can now be predicted to be its ultimate disposition.

As a case in point—New York City is contemplating a new commercial high school, some floors of which may be occupied by private enterprise—some compatible, rent-paying business concern whose customary occupation can provide real, rather than contrived, on-the-job training. Consideration is being given, too, to the design *of a building that will divide itself between schooling and housing: the first three floors, for example, could be for children at school; the remaining floors could be apartments. Such a school could grow or shrink according to the fluctuation of enrollment, moving into or withdrawing from space designed to accommodate either classes or families according to need—perhaps with a playground on the roof.*

This concept of joint occupancy raises new questions and new possibilities. If urban renewal is the aim, does it make sense to send the children from the new development to the surrounding slums for their education? Need we always have a separate school for children in early childhood, ages 4 to 10, when a massive housing development is created? May not the small children, who must be protected from traffic hazards, go to school at home in the housing project itself?

CHILDREN WILL LEARN FROM TEACHERS AND MACHINES

The advent of mechanisms for assisting the teacher will likewise reshape the schoolhouse. Consider that a half million pupils were receiving regular instruction by television as long ago as 1958. With airborne methods of telecasting, the number may approach five million in 1961, and with the development of more economical and simpler video-tape recorders, ultimately the numbers taught may approach the 43 million now enrolled in American schools.

Consider, too, that in our national intention to become a bilingual people, language laboratories are becoming the prevailing supplement to the voice of the teacher. The audio-tape recorders, cartridge-loaded to avoid the problems of rewinding; the overhead projectors; the teaching machines for which specific bodies of subject matter will be programmed in order that the student may confront and learn a body of knowledge at his own rate or on his own time; the Synchro-reader, about to become generally available, that brings into reality the "talking book" from which one child or many may learn through both eye and ear; video-sonics, simultaneous sight and hearing used so successfully in industry; all these and more will become the new tools for learning. They will strengthen the teacher, not replace him. They will free teacher and learner from the lockstep of standard groupism; the machines will speed communication between student and teachers, freeing each child to pursue knowledge proportionate to his talents and his drive. Ultimately the school will become as automated as the American home where the housewife has been freed of so many boring and laborious tasks.

In large schools and large school systems we can expect an increase in the use of electronic data processing to provide better information on which to base administrative decisions, to reduce the clerical work now performed by teachers, and to improve the efficiency of class scheduling in order to achieve more effective utilization of physical facilities.

As mechanisms come generally to be the necessary and ever present aids to teaching and administration, expenditures for equipment will grow larger in proportion to the cost of the building shell.

We can expect, too, an increase in the number of schools linked by closed-circuit television as a means of sharing faculty and resources. The small rural schools will be linked by television into regional networks, thus diminishing their cultural isolation and enabling them economically to offer courses ordinarily provided only by the larger urban or consolidated schools.

One-fifth of all public elementary and secondary schools in America are still one-teacher schools. However desirable is physical consolidation, the fact remains that thousands of them will have to remain small and isolated schools. Television, films, and video tapes offer intellectual and academic consolidation to these small but numerous islands in our culture.

THE ENVIRONMENT WILL BE DE-JUVENILIZED

The typical classroom today is a glass and masonry box filled with kitchen-like furniture. Its surfaces are hard and cold. Its furnishings and appointments are totally utilitarian. The hospital-like floor, the plastic desk top, the factory lighting fixtures, the painted cinder block, all suggest that the over-riding considerations are antisepsis and indestructibility. Nothing yields to the body, is soft to the hand, or warm to the eye. Connected by cavernous corridors of echoing tile and steel lockers, most modern classrooms are sterile and unyielding and institutional.

Several recent schools are striving to soften and humanize the environment of such quarters of the building as commons rooms, study quarters, and students centers. Gradually, furniture that is comfortable is being introduced. Some schools are searching for an acoustical and insulative floor covering, economical but more agreeable than today's hard and noisy surfaces that institutionalize the environment, make teaching harder, and are thought (erroneously) to delight the janitor. As more and more responsibility is placed on the child for his own learning, more dignity will be accorded him. The larger school especially will seek some measure of amenity to diminish the effect of its overpowering mass and the sense of anonymity induced by its hugeness.

Indeed, not only will the environment encourage the student to hasten his maturity but the management of students will move toward a more adult relationship with the student. In the secondary school the bells will cease to ring, the more mature and responsible students will be "de-scheduled" from the close control and maximum security regulations in force for the immature and irresponsible, and students will confront the prescribed bodies of knowledge, whether of school or college grade, when they are ready to profit from such study and not just when the subjects are offered in the course of study. To de-juvenilize the high school and hasten the maturity of students requires the closest of cooperation between educator and architect.

Look, too, for more large schools to be divided into schools-within-the-school, of "houses" in which the pupil feels at home because he senses that someone in authority knows him.

THERE WILL BE NEW FORMS AND SURFACES

The American schoolhouse, its shape and materials, has seldom varied from whatever was prevailing in its region at the time it was built. Experimentation and the emergence of new forms have not been characteristic of schoolhouse construction. Though there is no national system of education in America, our schools are as alike as though uniformity were compulsory and diversity were illegal.

Yet there has been some reaching out here and there for new forms. A case in point is the dome (geodesic and otherwise) now coming into use as a structure for large places of assembly and for gymnasiums.

Though the geometry of the geodesic dome was worked out by R. Buckminster Fuller in 1917 and over 500 have been built, only now is the structure being considered for public education. Wayland, Massachusetts, has a high school field house in a wooden dome, and Utica, Michigan, has also used such a dome for an auditorium. Pryor, Oklahoma, has an aluminum geodesic dome housing an auditorium.

New materials are coming into use in building and will be in the schools before long. Plastics are finding their way into building in ever increasing amounts. MIT is developing a school of steel and plastic. As the cost of conventional building materials mounts yearly while plastic prices come down, we can look for more plastics tomorrow. You will find plastics on the inside and outside surfaces, as insulation, pipes, and, often in combination with other materials, as structure.

The invention of the cheap, uniform, high quality nail once revolutionized American building practice. The development of new adhesives may do it again. We may soon be fastening our buildings together cheaply, quickly, and strongly with adhesives.

Look for new uses of old familiar materials. More and more wood will be laminated in various ways to serve as structural members, arches, and domes as well as surfaces. Concrete will be sprayed in new curvilinear forms as well as cast.

New materials and new uses of old materials will call for new forms. The box will not continue to be the almost universal building form. Arches, domes, hyperboloids, paraboloids are all here now and we will see more of them.

Some of our buildings will look lighter and less permanent than they ordinarily look now, and they will be less permanent. They won't look like today's conventional buildings which don't look like yesterday's conventional buildings.

THERE WILL BE A MORE PRECISELY CONTROLLED ENVIRONMENT

There are at least two architectural approaches to environment. One is to live with nature and use all the light, breeze, and beneficial climate available while blocking out the brutal glare, the cold wind, and the hot summer sun. In short, accept and use nature. The other approach is to block out nature insofar as we can. We can fabricate our environment with artificial light, air conditioning, and controlled sound. The precision with which environment can be controlled is increasing. There is no doubt as to ultimate direction: environment will be more and more controlled. In the school as in our other buildings we turn from nature to industry.

We know something about color, humidity, odor, heat, light, space, and air movement, but little of their combined impact on the processes contained within the school. When economy is equated to productivity, when the question of how much we are spending for a school is answered in terms of what we are getting out of it, the case for providing an environment that is controlled and automatic will be clear. Temperature, ventilation, humidity, light, color, texture, noise—all these will be regarded as factors in determining efficiency of output—i.e. learning—and not, as now, just factors of input—i.e. cost.

GROUPS OF SCHOOLS WILL BUILD TOGETHER

Today a school is specified by a school board, planned by an architect, and built by a contractor. These three partners may never have worked together before and may never work together again. Typically, building a school is a one-shot enterprise pursued without regard to similar enterprises that may be going on in the same or in adjoining municipalities.

In England the situation is different. In order to reduce the duplication of effort, to share resources, and to secure the benefits of group rather than individual action, the Ministry of Education encourages the formation of consortiums, the voluntary clustering together of school districts faced simultaneously with the planning and building of similar schools. Among the benefits accruing from the consortium is the attraction of major contractors who can deploy manpower and equipment with maximum efficiency—and consequent savings—among several projects. In America, in contrast, most schools are built by small contractors, many of them a job at a time. A single custom-built schoolhouse, we are told by several large general contractors, is a headache which they choose to avoid.

Recognizing this general problem, and eager to save time and money, several states have reacted by plumping for the opposite extreme—stock plans. This method involves the acquisition by the state of a number of "model" school plans which school boards may then order free of charge from the state according to which model seems to fit the local need best. Among the benefits claimed for this method are reduced architects' fees, reduction in time of planning and designing, and the establishment of state-endorsed standards of acceptability.

As with most issues whose extremes are so far apart, the truth will be found somewhere in the middle, in this case somewhere between the present practice of building in solitary isolation and the opposite extreme of offering mail order schools which, like Howard Johnson restaurants, dot the countryside. And there is a middle ground: not stock plans but stock components; not whole schools but the parts and pieces that go together to make a school.

The movement toward this middle ground, wherein lies greater economy of effort and money, will be hastened as modular measure comes into more general use. Modular measure makes possible the dimensional coordination of materials so that they may be mass-produced and incorporated in a structure without modification. The reduction of building construction costs through modular measure has been a matter of study in the United States since 1921. In 1934 the movement toward modular measure, or modular coordination, as it was then called, was promoted by the National Bureau of Standards of the United States Department of Commerce. Brick makers and metal window manufacturers were among the first to cooperate. In 1945 the American Standards Association approved the 4-inch module as an American standard suitable for dimensional coordination. In 1953 in Europe, ten countries, at the suggestion of the United Kingdom, joined in efforts to establish a European module. Currently the American Institute of Architects, the Associated General Contractors of America, the National Association of Home Builders, and the Producers' Council are jointly sponsoring the Modular Building Standards Association to promote modular measure in the United States. Modular measure has not yet taken hold in school construction—only about one school building in ten is modular—despite the savings that could accrue from reduction in (1) range of product size, (2) cutting and fitting on the job, (3) cost of designing and detailing, and (4) cost of estimating.

In the long run, economy in school building will be better served by encouraging experimentation and diversity of design. Particularly in these times do we need to encourage the new and unfreeze the old because education itself is in flux. Great changes are taking place in what and how to teach. Even the word "classroom," which historically has meant a square or rectangular box of fixed dimension, is having to extend its definition to mean a general ratio of space to pupils, alterable according to the task at hand. Someday we shall come to speak of spaces for learning, not classrooms for teaching.

As educators improve their descriptions of what should be going on in the school, as architects are encouraged to design imaginatively around such descriptions, and as groups of school boards build together rather than alone, more economical and better functioning schools will come about.

IN SUM

The demographers tell us that our population will double by the year 2000! In a sense this means that in the next 40 years we must build another—an additional—America.

The schoolhouse—the most numerous of public structures, the one that more people care about than any other, and have more to say about than any other—must carry its share of the burden of change. As you and educators and architects and citizens put together tomorrow's schools, think about these things:

- Anticipate—schools are usually planned too fast.
- Think first of what you want the school to produce before you decide what to put in it.
- Don't plan in isolation—your neighbors have the same problems.
- Don't buy permanence at the expense of performance. We're in a period of rapid cultural change; don't saddle us with unchangeable schools that will some day "sit beside the road, a ragged beggar, sunning."
- If you're not sure how long the school will be needed, consider high quality, transportable space. If you're wrong, you can recapture your equity—and your equanimity.
- Don't be afraid of new forms and shapes. Eventually it will be cheaper to get space by scooping a cavity out of the sky, rather than by scooping it out of the earth or piling up small blocks as the Egyptians did to surround space.
- Plan the building to be a gentle place for children and a machine for learning.
- Don't spend all your time on the structure—the tools you give the teacher are just as important. A beautiful library with no books jeopardizes our security as a nation. Schools are not to package education but to speed it.
- Write good educational specifications. If you don't describe what you want to go on in the building, how can the architect put an envelope around it? He'll do the architecture if you'll do the education.
- If you decide on variable or flexible spaces, be sure to provide money for helping the teachers to exercise their new freedom. Otherwise they may reconstitute their box-like nests from instinct and habit.
- Resist stock plans unless you're too busy to work with the educators and the architect. In the long run it will cost you money to order a school through the mail.
- Watch out how you borrow money. We found a case where a school board paid for one building two and a half times: once to the contractors and one and a half times to the bond holders.
- The best architect costs the same as the poorest—and the difference to your building can be as much as 5 per cent in cost and 100 per cent in performance.

- Encourage imagination in your architect and experimentation in your educator. Don't evade your responsibility for finding answers to some of the unknowns.

- In general, building codes lag behind the times. If, after appeal, the rules, regulations, or interpretations by various governmental bureaus still seem punitive to the building, the program, and the budget, call a press conference and say so. A. M. Watkins in Harper's (February 1960) describes home building codes as "wildly archaic . . . a principal obstruction to the use of money-saving standardization and mass-production techniques in house construction." And the schoolhouse is not far behind.

- Don't look at a particular school as the final solution to the housing of education for its neighborhood. The school is but a servant of our changing culture. Let some other municipal department build the monuments while you build structures that yield willingly to the future; indeed, use the building to lead the neighborhood toward its own revitalization and renewal.

- A building is an organic whole and should be designed as a whole from the inside out. Don't fetter the architect by prescribing details before he begins. When he has put the whole together and the details have fallen logically into place, then apply the test of economy.

And finally, education is for perpetuating and, hopefully, improving our culture by transmitting it to the young. The schoolhouse is not, of course, as important as the school teacher. But the schoolhouse, because it stands there to be seen, speaks of the intentions of the community toward the children. Any school you build either helps to anchor the people to the community or, instead, hastens their departure. The schoolhouse more than any other structure in town declares the public intention to press on, to rest awhile, or to go back. Winston Churchill said it best: "We shape our buildings; thereafter they shape us."

Acknowledgements

A publication dealing with school building costs is limited by the availability of precise and reliable cost data. It seems obvious that it ought to be possible to make rather exact statements about a topic which deals with the cost of bricks, cement, desks, bookcases, boilers, and kitchen equipment — and the cost of putting these together to produce a school. But the obvious is deceptive. There are almost as many different statistics on school costs as there are board members, taxpayers associations, architects, and city councilors. Data on school building costs — and indeed building costs in general—appear to be in a state of relative imprecision.

To bring order and accuracy to discussion of cost will require the substitution of analysis for opinion and measurement for rule of thumb. There is even need for such an elementary step as coming to agreement on terms. Meanwhile, hundreds of schools will have been built by school boards throughout the country.

Acknowledging these limitations, this report is presented to assist school board members in coming to a better understanding of some of the elements of school building costs and to help them in asking the kinds of questions which may make it possible to secure more efficient buildings with economy.

Manuscripts on major topics were invited from authorities in their respective fields; from these, the staff of the Educational Facilities Laboratories developed the present document. In this process it is inevitable that some of the original authors' materials have been absorbed in other topics or, because of lack of space, abbreviated or omitted. The responsibility for the statements and the position presented here must therefore rest with the staff of EFL and not with the contributors.

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However, the full responsibility for **The Cost of a Schoolhouse** must be taken by the EFL staff.

Reports on EFL Activities

EFL PUBLICATIONS

Available without charge from
Educational Facilities Laboratories, Inc.
477 Madison Avenue
New York 22, New York

Here They Learn
EFL's first annual report, September, 1959.

Ring the Alarm!
A memo to the schools on fire and human beings, November, 1959.

Profiles of Significant Schools
A series of reports which provide information on some of the latest developments in school planning and design.

Design for ETV—Planning for Schools with Television
A report on facilities—present and future—needed to accommodate instructional television and other new educational programs. Prepared for EFL by Dave Chapman, Inc., Industrial Design, May, 1960, 96 pages.

EFL PROJECT PUBLICATIONS

Standards for Materials and Equipment for the Improvement of Instruction in Science, Mathematics, and Modern Foreign Languages, Council of Chief State School Officers, Washington, D. C., 1958. Available without charge from EFL.

Criteria and resource references to guide schools in establishing standards for materials and equipment in the above fields.

Purchase Guide for Programs in Science, Mathematics, and Modern Foreign Languages, Council of Chief State School Officers, Washington, D. C., 1959, 336 pages. Available from Ginn and Company, Boston, $3.95.

Recommended technical specifications on almost 1,000 items of equipment. Includes sections on how to use equipment, in what grade, priorities for equipment purchases, and an annotated list of books, magazines and pamphlets in the three fields.

Selected Reprints of Articles on Physics Buildings, Project on Design of Physics Buildings, American Association of Physics Teachers and American Institute of Physics, New York, 1959, 183 pages. Available from the American Institute of Physics, New York, $2.00.

Reprints assembled to aid in planning new physics facilities.

Operation School Burning, National Fire Protection Association, Boston, 1959, 296 pages. Available from the NFPA, Boston, $4.75.

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Developing the Educational Concepts, Specifications and Preliminary Plans for Marie Creighton Junior High School, Jefferson County, Colorado, Educational Planning Service, Colorado State College, Greeley, 1959. Available without charge from the Educational Planning Service.

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Planning a multi-purpose facility designed for maximum space utilization, and for both instructional activities and community use.

Crawford High School Plans Ahead (San Diego), School Planning Laboratory, Stanford University, Stanford, California, 1959. Available without charge from the School Planning Laboratory.

Report on the educational specifications for an addition to a new high school, resulting from a workshop analysis of new trends in secondary education and their implications for school design.

A Plan for Action, University of Alaska, College, Alaska, School Planning Laboratory, Stanford University, Stanford, California, 1959. Available without charge from the School Planning Laboratory.

Prospectus of the present problems, possible future developments, and long term goals for the University.

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"Educational Facilities Laboratories Decries 'Egg-crate' Uniformity," **School Planning,** Fall, 1959, pp. 22-23.

Report of EFL's first year.

"Audio Research for Language Laboratories," **Catholic Property Administration,** May-June, 1959, pp. 174-177.

Describes the two-year research study at Massachusetts Institute of Technology and Purdue University, supported by Educational Facilities Laboratories.

"Smoke is the Killer," George Reasons, **College and University Business,** April, 1960, pp. 61-63.

Report of the school fire safety tests in Los Angeles.

Quarterly, Vol. 53, No. 1, National Fire Protection Association, Boston, 1959, pp. 7-27.

Informal report on the Los Angeles open stairway school fire tests by Raymond Hill of the Los Angeles Fire Department.

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A guide to good practice for the design of college physics facilities. American Institute of Physics and the American Association of Physics Teachers. Summer, 1960.

An analysis of the cost and educational adequacy of school building projects begun since World War II in Chicago. Board of Education of the City of Chicago. Summer, 1960.

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Architects Charles R. Colbert, Don Barthelme and Mario Ciampi translate J. Lloyd Trump's ideas for reorganizing the secondary school program into design plans, following the University of Michigan workshop on "New Schools for New Education."

"Two Loft Schools: New Instruments of Education" and "School With Changeable-Area Teaching Spaces," **Architectural Record,** February, 1960, pp. 196-203 and pp. 212-213.

Architect John Lyon Reid adapts two existing school designs to J. Lloyd Trump's plan, following the University of Michigan workshop.

Marie Creighton Junior High School, Jefferson County, Colorado—school with divisible areas for teaching and assembly spaces.

"The Productivity Push in Schools" and "New Ways to Cut Costs," **Architectural Forum,** November, 1959, pp. 110-115 and pp. 125, 206-218.

Trends in secondary education bring new educational concepts and new school building design.

New school economies revealed by Educational Facilities Laboratories' survey of 100 secondary schools.

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Harold B. Gores, EFL president, describes new directions in education and school building.

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Comparison of British and American school building by two architects from the British Ministry of Education, who spent several months traveling in the United States studying our schools.

"Multi-Use Instructional Center Replaces Auditorium Idle 90 Per Cent of the Time," **Nation's Schools,** March, 1960, p. 118.

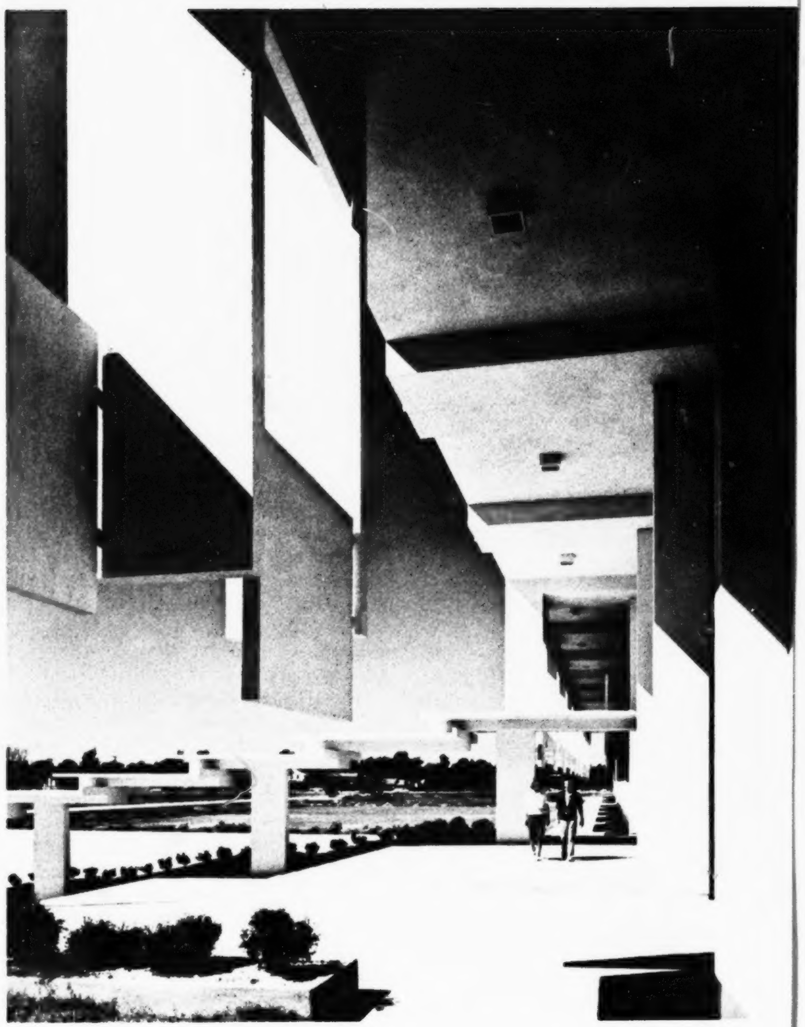
New flexibility in the educational program with the use of a divisible auditorium.

"Here Are Some Factors That Affect Future Schoolhouse Planning," **Nation's Schools,** April, 1960, pp. 74-77.

Interview with Harold B. Gores on current developments in the school program and their influence on building design.

"New Lab to Study Plant Problems," **School Executive,** December, 1958, pp. 21-24.

Harold B. Gores describes the origin, purposes, and planning of Educational Facilities Laboratories.



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P.77: Courtesy **Overview.** Port Isabel High School, Port Isabel, Texas; C. Lyman Ellis and Company, architects
Courtesy Unistrut Corporation. Hoover School, Wayne, Michigan; C. W. Attwood, architect
P.79: Morley Baer. San Lorenzo Valley High School, Felton, California; John Lyon Reid and Partners, architects
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Joseph W. Molitor. Tokeneke Elementary School, Darien, Connecticut; O'Connor and Kilham, architects
Hedrich-Blessing. Horace Greeley High School, Chappaqua, New York; Perkins and Will, architects
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